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**HONEYWELL
INFORMATION
SYSTEMS INC.**

TITLE:

No. 43A177737

ENGINEERING PRODUCT SPECIFICATION - 2
6000 Core Storage Unit
Power System

Total Pages 82

Page 1

REVISION RECORD

REVISION LETTER	DATE	PAGES AFFECTED	APPROVALS	AUTHORITY
A ISSUED	NOV 22 1971	1, 2, 2.1 2.2, 3-80 F	BH Meyer	11 Oct 71

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TABLE OF CONTENTS

1.	POWER SYSTEM (GENERAL) -----	3
1.1	PHYSICAL CONFIGURATION -----	3
1.2	POWER DISTRIBUTION -----	4
2.	BASIC & DETAILED DESCRIPTION OF OPERATION ---	8
2.1	A-C POWER COMPARTMENT (43D228350G1) ---	8
2.2	OPERATOR CONTROL PANEL -----	10
2.3	TRANSFORMER-RECTIFIER (43D222260) -----	13
2.4	LV REGULATOR MODULE, 43D222270 -----	18
2.4.1	General Description -----	18
2.4.2	Module Voltage Distribution (Internal) -----	22
2.4.3	Theory of Regulator Operation -	24
2.4.3.1	Basic Control Loop --	26
2.4.3.2	Over/Undervoltage Confidence Cir- cuitry -----	31
2.4.3.3	Overvoltage/Crowbar Circuitry -----	32
2.4.4	Panel Controls -----	34
2.4.4.1	Metering/Rotary Switch -----	34
2.4.4.2	Voltage Adjustment Potentiometers ----	35
2.4.4.3	Margin Switches -----	36
2.4.4.4	Status Indicators ---	36
2.4.4.5	Magnetics Tempera- ture Warning Indicators -----	37
2.4.4.6	Reset Buttons -----	38

2.5	HIGH VOLTAGE MODULE (43D222280G2) -----	38
2.5.1	General Description -----	38
2.5.2	Module Voltage Distribution (Internal) -----	42
2.5.3	Theory of Regulator Operation -	44
2.5.3.1	Basic Control Loop --	46
2.5.3.2	Over/Undervoltage Confidence Cir- cuitry -----	51
2.5.3.3	Overvoltage/Crowbar Circuitry -----	52
2.5.3.4	Softstart/Overcur- rent Circuitry ----	54
2.5.4	Panel Controls -----	56
2.5.4.1	Metering/Rotary Switch -----	56
2.5.4.2	Voltage Adjustment Potentiometers ----	57
2.5.4.3	Margin Switches ----	57
2.5.4.4	Status Indicators ---	57
2.5.4.5	Reset Pushbutton ----	58
2.6	POWER SYSTEM ON/OFF SEQUENCING -----	59
2.6.1	Power ON Sequence -----	59
2.6.2	Power OFF Sequence -----	64
2.6.2.1	A-C Power Shutdown --	64
2.6.2.2	Over/Undervoltage Confidence Shut- down -----	67
2.6.2.3	Overvoltage/Crowbar Shutdown -----	68
2.6.2.4	Overcurrent Shutdown-	68
2.7	TEMPERATURE CONTROL -----	69
2.7.1	Overtemperature Warning -----	69
2.7.2	Overtemperature/Overvoltage Shutdown -----	71

HoneywellRev. *A*

Page 2.2

2.8	LAMP DRIVER CIRCUITRY -----	73
3.	MAINTENANCE CONSIDERATIONS -----	74
3.1	PERFORMANCE CHECKS -----	74
3.2	MAINTENANCE CHECKS -----	74
3.3	ADJUSTMENT PROCEDURES -----	74
3.4	DISASSEMBLY AND REPAIR -----	75
3.5	MAINTENANCE AIDS -----	75
4.	INSTALLATION REQUIREMENTS -----	75
5.	APPENDIX -----	76
5.1	POWER SUPPLY ELECTRICAL SPECIFICATIONS --	76
5.2	POWER SYSTEM DRAWINGS -----	78

1. POWER SYSTEM (GENERAL)1.1 PHYSICAL CONFIGURATION

The power system to be described is used in four different Core Storage Units. Table 1 lists them by model number.

Table 1 - Core Storage Units

<u>MODEL NUMBER</u>	<u>MEMORY SIZE (WORDS)</u>	<u>SPEED (μSEC.)</u>
4WMM8033AA1	32K	0.5
4WMM8034AA1	64K	0.5
4WMM8035AA1	32K	1.2
4WMM8036AA1	64K	1.2

The basic or minimum power system consists of four basic parts. They are listed in Table 2. This configuration is required for a 32K word memory.

Table 2 - Power System Components

<u>DESCRIPTION</u>	<u>DRAWING NUMBER</u>
1. A-C Power Compartment (Care Package)	Assembly - 43D228350 Schematic - 43D228352
2. Transformer-Rectifier TR (A1 Location)	Assembly - 43D222260 Schematic - 43D222252
3. Low Voltage Regulator LV (A2 Location)	Assembly - 43D222270 Schematic - 43D220576
4. High Voltage Regulator HV (A3/A4 Location)	Assembly - 43D222280 Schematic - 43D233546

To expand to a 64K word memory, one additional high voltage regulator module is required. Figure 1 illustrates this physical configuration and the module designators identify their types and positions. Recognize that high voltage module A3 is identical in every way to high voltage module A4. They differ only in location and to some extent in the way they are wired into the power harness. These differences are discussed later. Both configurations use the same A-C Power Compartment and Operator Control Panel.

1.2

POWER DISTRIBUTION

Three-phase, 208 VAC is used to power the Core Storage Unit. It connects to the cabinet through the A-C Power Compartment. For the organization of the power distribution within the cabinet refer to the block diagram in Figure 2. Detailed wiring is shown on drawings 43D231888 and 43D272251.

A three-phase circuit breaker located in the TQL box on the A-C Power Compartment controls all power applied to the cabinet. Whereas, the Operator Control Panel controls power applied to the transformer-rectifier (A1) and all fans through the main a-c contactor. Whenever the main circuit breaker is on, a +24 volt power supply within the power compartment is energized. This voltage is used to control On/Off relays, power status indicators on the operator's panel, and other circuitry used to operate the alarm bell, which may be activated by overtemperature thermostats within the power system or magnetics modules.

The transformer-rectifier (A1) is a bulk power supply that provides five unregulated d-c voltages to the low and high voltage regulators. Its distribution is illustrated in Figure 2. The d-c voltages are derived from three-phase bridge rectifiers connected to output filter capacitors. Table 3 lists the voltages provided by the TR and the regulators that use these voltages. A circuit breaker protects each output in the event of a overload.

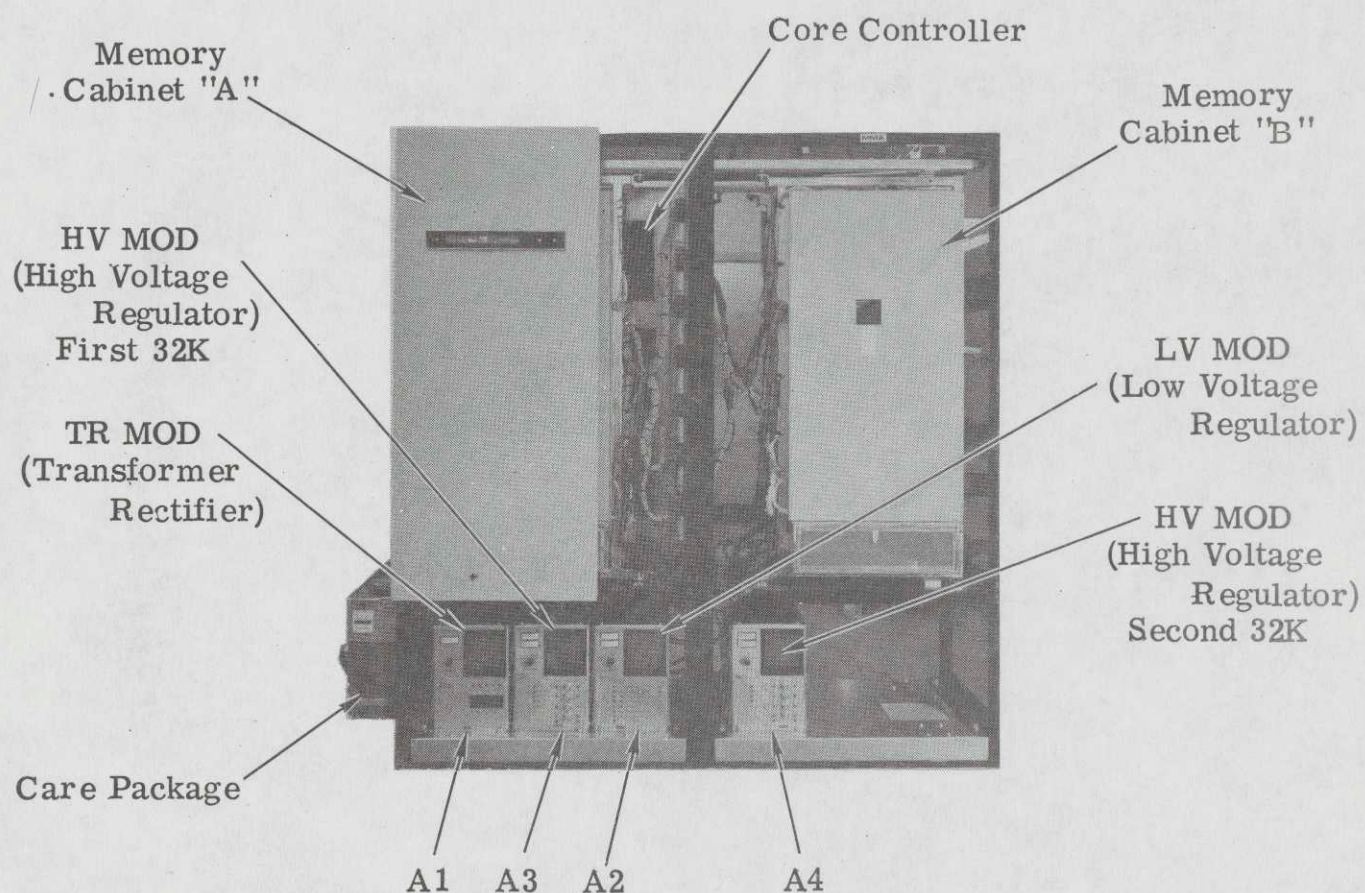


Figure 1 Memory Power Supply Placement
(Front View)

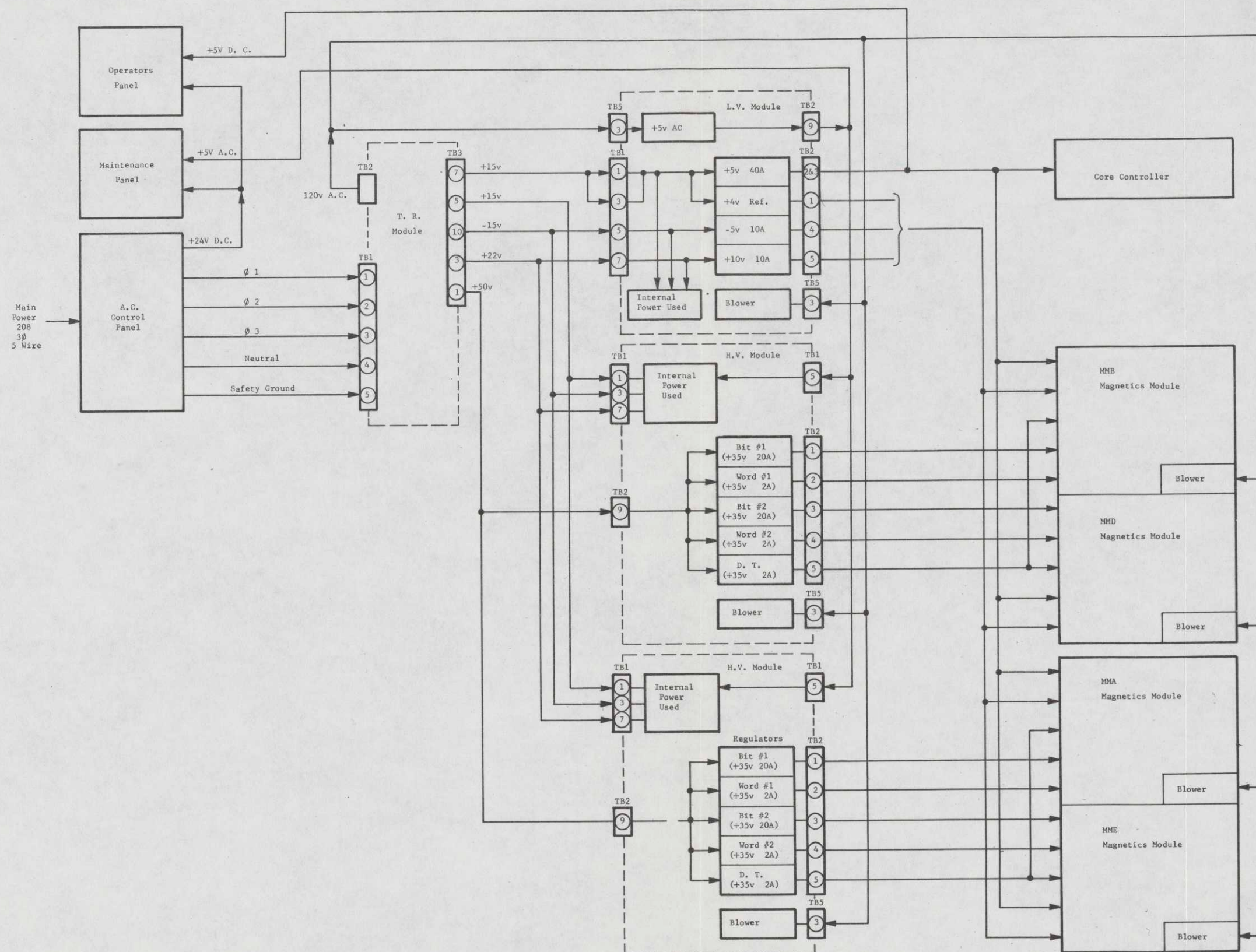


Figure 2
Block Diagram of Voltage Distribution

Table 3 - TR Voltage Outputs

<u>VOLTAGE/CURRENT</u>	<u>REGULATOR</u>
+15 vdc @ 40 Amp. (CB4)	LV +4, +5 volts
+15 vdc @ 10 Amp. (CB3)	HV Internal
+22 vdc @ 10 Amp. (CB2)	LV +10 volts
-15 vdc @ 10 Amp. (CB5)	LV -5 volts
+50 vdc @ 40 Amp. (CB1)	HV Bit, Word & DT

The low voltage regulator (A2) provides four regulated voltages: +5, +4, +10 and -5 volts. The +5 volts is used by the TTL circuitry in the Core Controller and the sense amplifiers in the magnetics modules. The +4 and -5 volts also are used by the sense amplifier, whereas the +4 volts is used as a reference voltage. The +10 volts is used by the word, bit and DT driver, in the magnetics modules.

The low voltage module provides one additional voltage that is used to power all indicators on the Maintenance Panel, as well as in the A2, A3, and A4 modules. It is an unregulated 5 VAC full-wave rectifier voltage.

The high voltage module (A3 and A4) provides five regulated voltages; four of which are adjustable between +24 and +38 volts. Two are for Word Drive lines (low current) and two are for Bit Drive lines (high current). The fifth voltage is nominally set at +32 volts and is used to power the distributed transformers in the magnetics modules.

The actual voltages to which the bit and word regulators are set is a function of the particular magnetic module and its driver requirements (based on "shmoo profile"). Typically, these are set at around +31 volts.

120 volts ac is distributed to the fans located in each magnetics module (three per magnetics module) and power supply module (one per module).

For a complete list of specifications for each module refer to the Appendix 5.1.

2. BASIC & DETAILED DESCRIPTION OF OPERATION

2.1 A-C POWER COMPARTMENT (43D228350G1)

Figure 3 shows the layout of the component parts within the A-C Power Compartment. Detailed wiring is shown on schematic 43D228352.

The main circuit breaker, CB1, controls all a-c power to the Core Storage Cabinet. It is located in the TQL box to which the five wire power cable is connected. When the breaker is closed a-c voltage is applied to the main contactor (K5), the +24 volt dc power supply and the running time meter (M1). It is a three pole breaker which opens if the current in any phase exceeds 20 amperes.

The +24 volt dc power supply provides an unregulated voltage for operating all relays in the power compartment, the alarm latch printed circuit board (A1) and the indicators on the operator control panel (MP2). It consists of a step down transformer, T1, a full-wave bridge rectifier (CR1 to CR4), an output filter (C16) and a bleeder resistor, R1. The primary of T1 is connected to Phase A and fused with a 2 ampere slow-blow fuse which is located directly above the running time meter. The output is available on TB3.

The running time meter, M1, operates whenever the main circuit breaker is closed and it displays the operating time in hours and tenths of hours.

Once the main circuit breaker, CB1, is on, the Operator's Panel controls power applied to the cabinet. Power is turned on by depressing the ON pushbutton on the Operator's Panel. This energizes the Power-On relay, K1, which in turn pulls in the

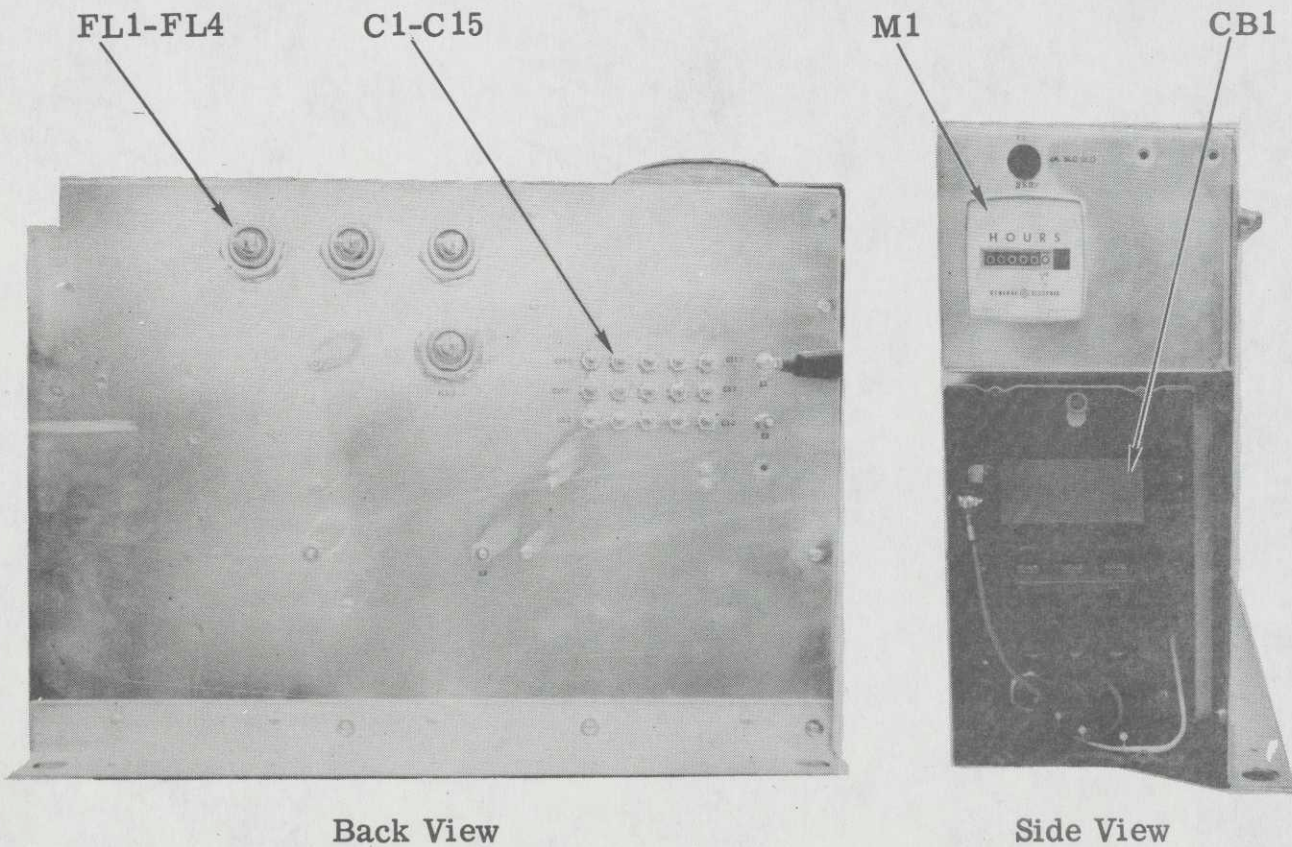
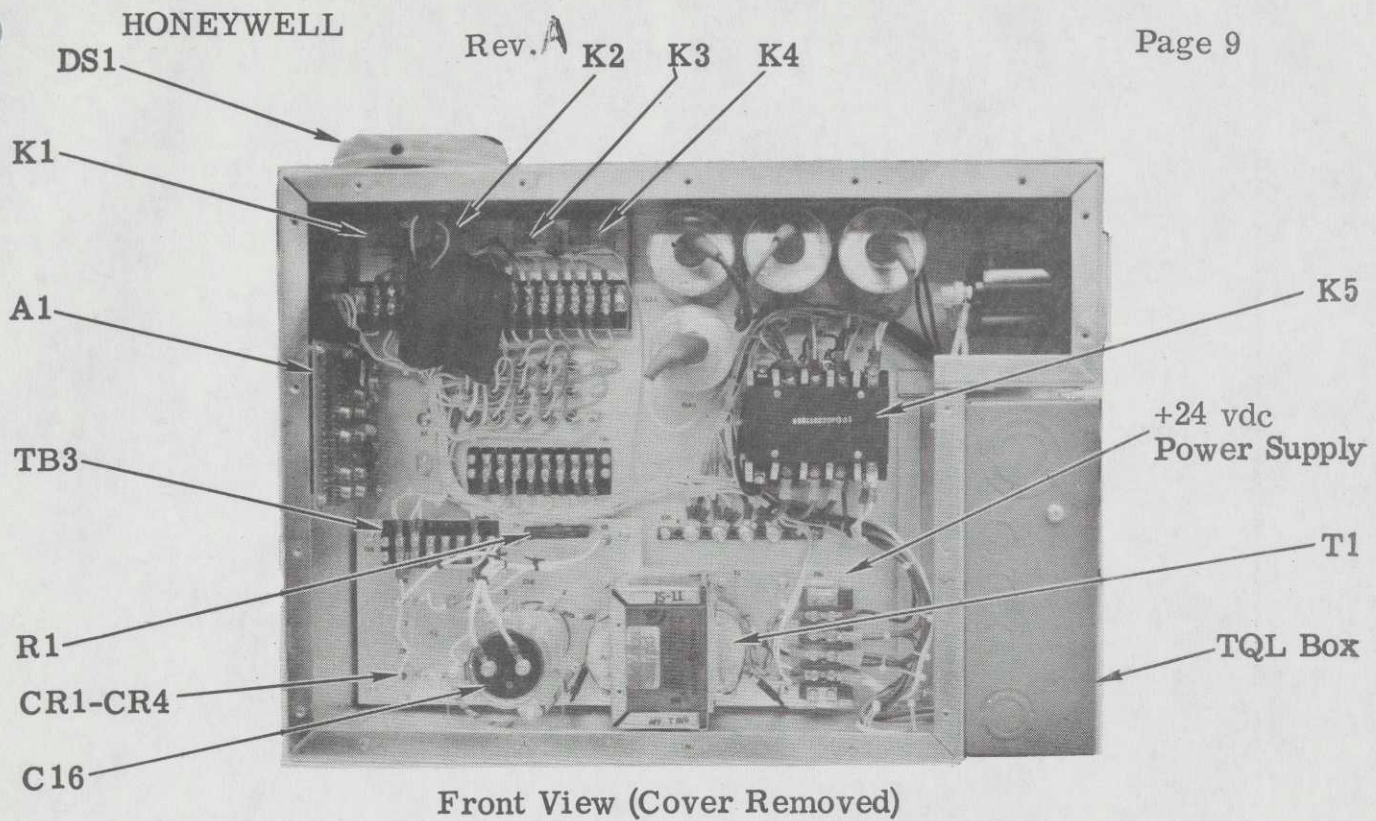


Figure 3 AC Power Compartment (Care Package)

main contactor, K5, and applies ac to the TR (A1) through the line filters (FL1 to FL4). Depressing the OFF pushbutton on the Operator's Panel, energizes the Power-Off relay, K2, which operates the holding circuits for K1 and K5.

Two other conditions can cause the K2 relay to operate, both of an emergency nature: thermal shutdown due to an overtemperature in one of the modules (A1 to A4) or an overvoltage shutdown due to a defective low or high voltage module (A2, A3, A4).

The overtemperature (K3) and alarm (K4) relays operate whenever the temperature in the magnetics or power supply modules reach a critical operating point. Whenever a temperature warning thermostat is activated K3 is energized. This sets the alarm latch circuitry (A1), which in turn energizes K4 and the bell (DS1). An operator must manually depress the ALARM RESET button on the Operator's Panel to turn off the bell. However, the OVER TEMP indicator will remain on as long as the overtemperature condition exists.

Resistors (R1 to R4) discharge the energy stored on the line filters (FL1 to FL4) whenever K5 is open. Whereas, the diodes (CR5 to CR9) discharge the relay energy whenever they are deactivated.

Filter capacitors (C1 to C15) provide noise filtering for the control lines between the A-C Power Compartment and the cabinet.

2.2 OPERATOR CONTROL PANEL

The operator control panel consists of seven indicators, three normally open pushbutton switches and a lamp driver PWB. The seven indicators, three of which work in conjunction with the pushbutton switches, are located on the front of the control door. However, the terminal boards and lamp driver PWB are on the inside, directly behind the indicator assemblies. Figure 4 illustrates the control panel indicators.

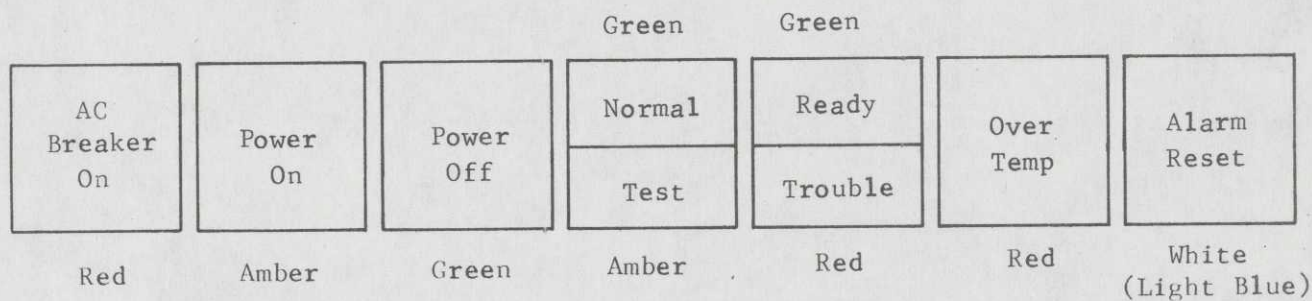


Figure 4. Operator's Panel

The AC BREAKER ON (red) indicator shows the status of the main current breaker (CB1). When lighted it is closed.

The POWER ON (amber) indicator/switch is depressed to energize the main a-c contactor as described in paragraph 2.1. When the contactor operates, the amber indicator lights, and ac is applied to the TR and cabinet fans. Just closing the main a-c circuit breaker will not apply power to the cabinet, the POWER ON pushbutton must be depressed.

The POWER OFF (green) indicator/switch is depressed to de-energize the main a-c contactor. It is lighted when the contactor is open.

The NORMAL (green)/TEST (amber) and READY (green)/TROUBLE (red) indicators display the mode of operation and status of the unit respectively. Refer to the Core Storage product description for an explanation of these indicators. These are controlled by the lamp driver PWB (A1), however.

The OVER TEMP indicator is lighted whenever an overtemperature warning occurs within the Core Storage unit. This condition activates the alarm latch and bell, causing the ALARM RESET indicator/switch to be lighted. Depressing the ALARM RESET pushbutton turns off the bell and turns off the light. But the OVER TEMP indicator remains lighted as previously described.

Plus 24 volts and plus 5 volts are used to operate the circuitry on the operator's panel.

2.3

TRANSFORMER-RECTIFIER (43D222260)

The transformer-rectifier (TR) module is a bulk unregulated dc supply capable of supplying approximately 3K va of power. The schematic of this module is 43D222252 and shown in Figure 5. This module also is used as a distribution point (TB2) for the 120 VAC single phase ac used by the fans in the cabinet (reference 43D231888).

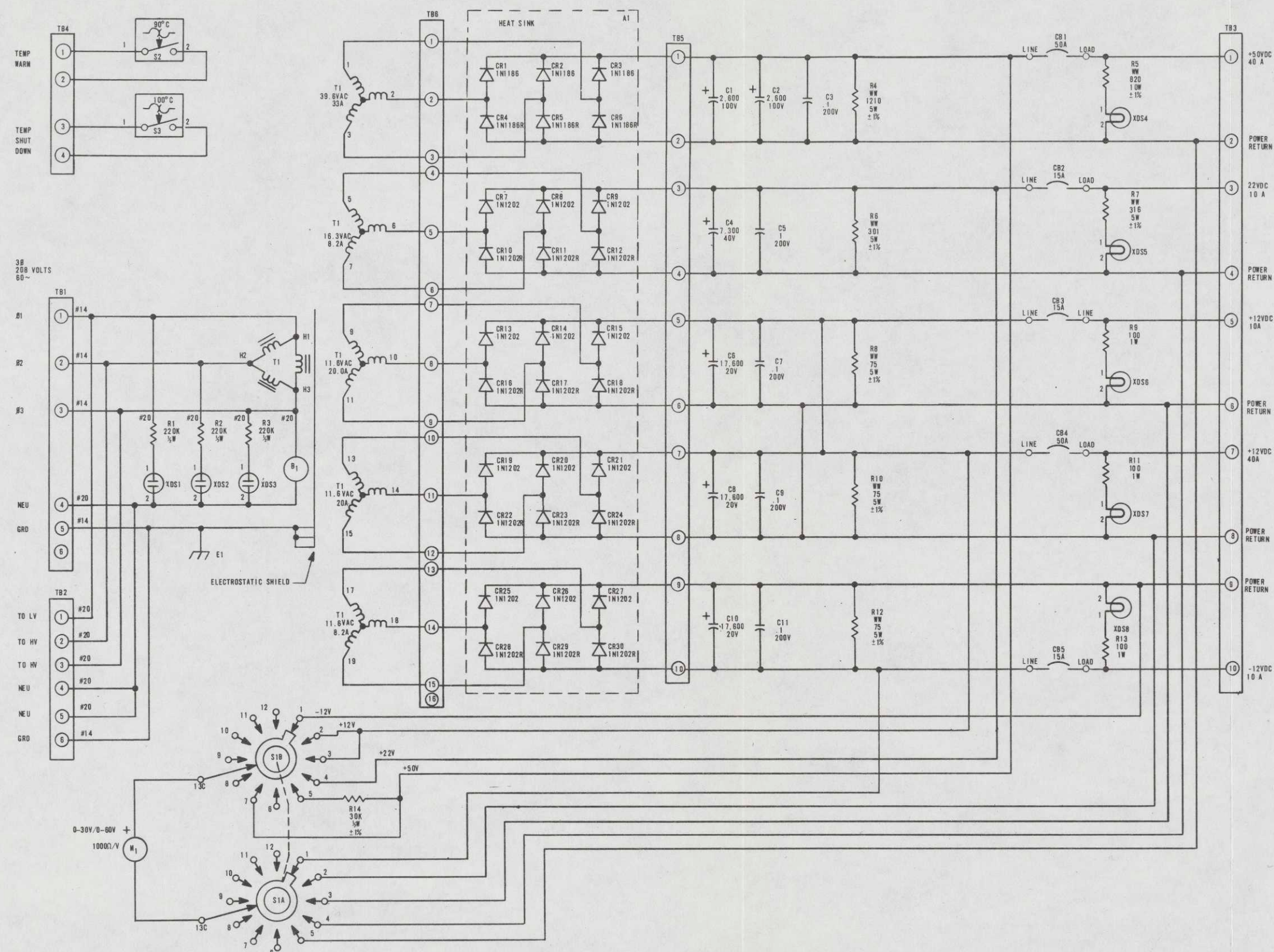
Circuit breakers protect each of the voltage outputs, and they may be used to control the d-c voltages to the power system when servicing the equipment. Circuit breaker ratings and identities are shown in Figure 5. The distribution of the output voltages are summarized in Table 3. Figures 6a and 6b show the module and the location of the various component parts.

Three phase ac is brought into the TR via TB1 which is located on the rear of the module. From TB1, phases A, B, and C are connected to the primary of the main transformer (T1).

T1 is a delta-wye step down transformer, with five independent secondaries: three windings are rated at 11.6 VAC/20 Amp., one winding at 16.3 VAC/8.2 Amp., and one at 39.6 VAC/33 Amp. The transformer has a Faraday shield that is connected to safety ground and isolates the secondary from the primary electrostatically. The transformer is convection cooled by air circulating through perforations in the bottom and sides of the module.

Three phase full-wave rectifiers mounted on heat sink (A4) process and provide unregulated d-c voltages for the high and low voltage modules. A fan cools the heat sink, which mounts 30 power diodes (CR1 to CR30).

Maintenance personnel are urged to periodically clean the intake filters and any dust accumulation to ensure proper airflow through the heat sink and around the transformer.



3. ALL WIRE GAUGES ARE A.W.G.
2. ALL RESISTANCE VALUES IN OHMS $\pm 5\%$.
1. ALL CAPACITANCE VALUES IN MICROFARADS.

NOTES: UNLESS OTHERWISE SPECIFIED:

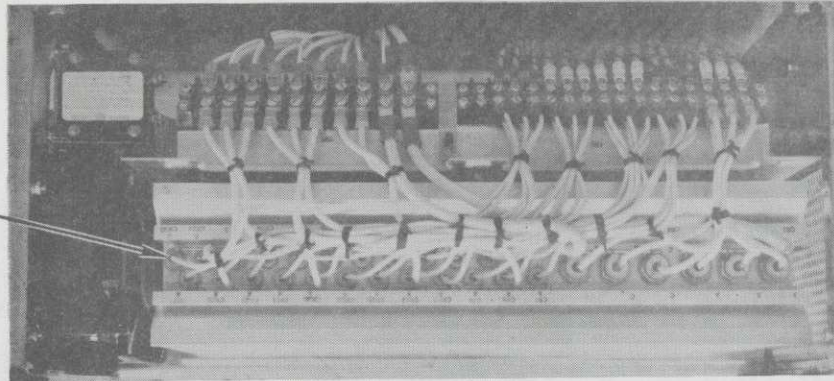
Figure 5 Transformer Rectifier Schematic

HONEYWELL

Rev. A

Page 15

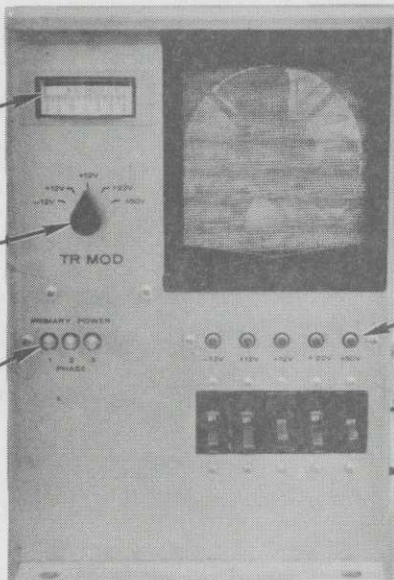
CR1-CR30



Top View

M1

S1

XDS1
- XDS3

Front View

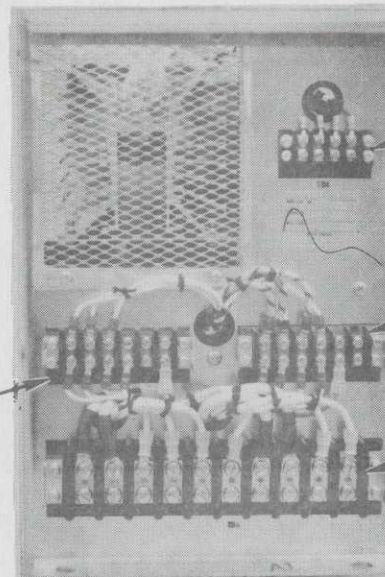
XDS4
- XDS8

TB2

TB4

TB1

TB3

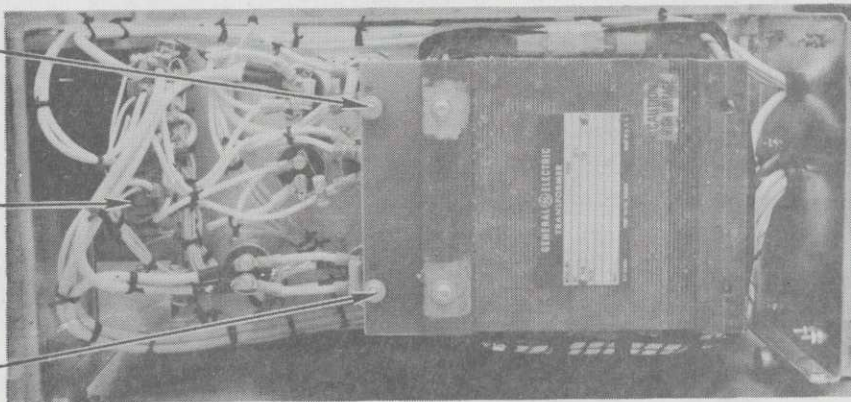


Back View

S2

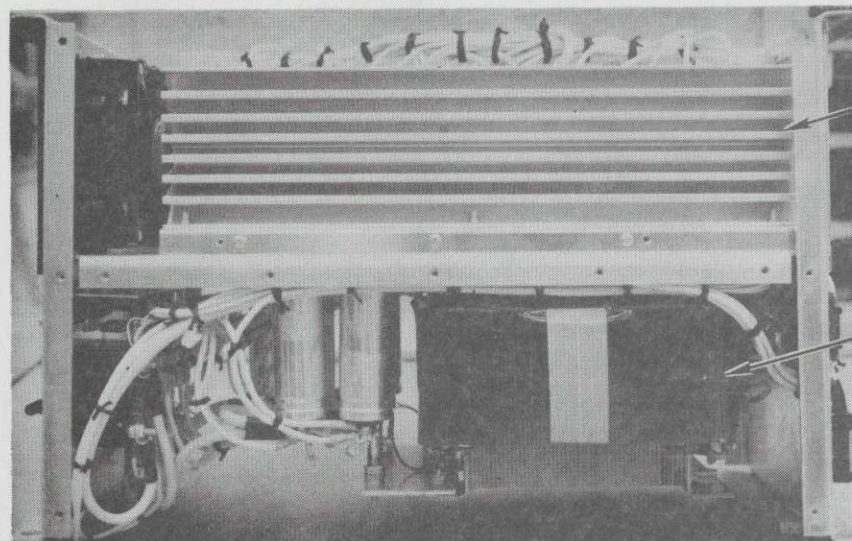
R4, R6, R8,
R10, R12

S3

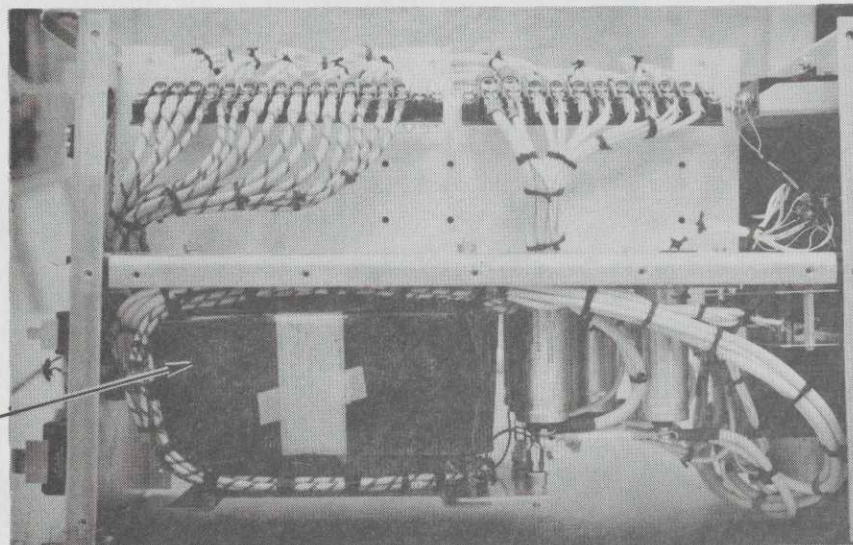


Bottom View

Figure 6a Transformer Rectifier Module (A1)



Right Side View



Left Side View

Figure 6b Transformer Rectifier Module (A1)

The output voltage from each bridge is filtered and connected through a circuit breaker to the output terminal board (TB3). Note that the +15 volt, 40 ampere and 10 ampere outputs are connected in parallel internally, but distributed to TB3 through individual circuit breakers. Bleeder resistors (R4, R6, R8, R10, R12) discharge the output capacitors whenever power is removed.

Three neon indicators (XDS1 to XDS3) are connected between each input phase and neutral. Whenever the main contactor is closed in the A-C Power Compartment these should be lighted. Loss of one phase will be indicated and cause premature damage to the TR.

Incandescent indicators (XDS4 to XDS8) are connected across each independent output and are lighted whenever their associated circuit breakers are closed.

Temperature warning (S2) and shutdown (S3) thermostats monitor the internal module air. The normally open sensors are connected to TB4 and the external control logic. Refer to Section 2.7 which discusses the operation of this logic.

Voltmeter (M1) and Selector Switch (S1) located on the front panel, permit maintenance personnel to monitor the output voltages on TB3. The 0 to 60 volt range on the meter is accurate to $\pm 3\%$.

2.4 LV REGULATOR MODULE, 43D222270

2.4.1 General Description

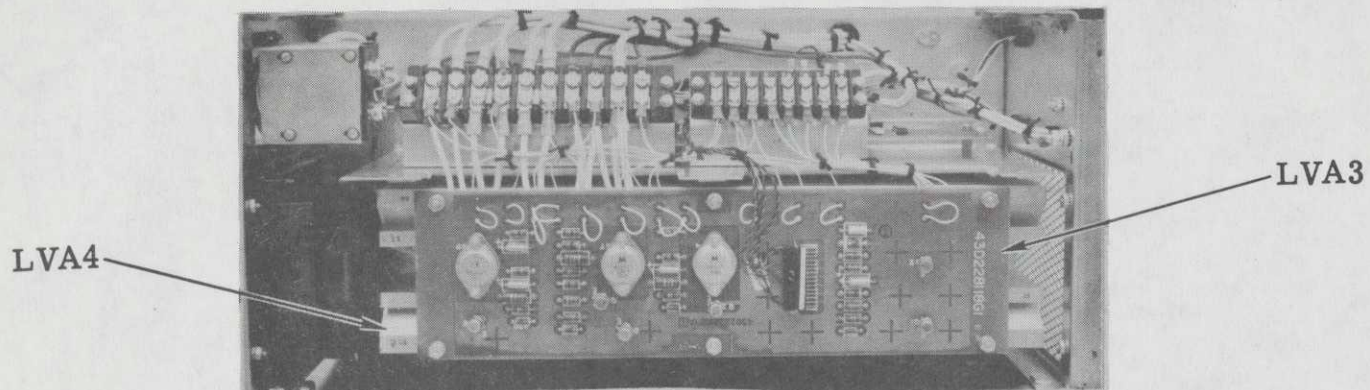
The low voltage module contains four low voltage regulators. Table 4 summarizes their ratings and application. A detailed specification of each regulator can be found in Appendix 5.1.

Table 4 - LV Regulator Outputs

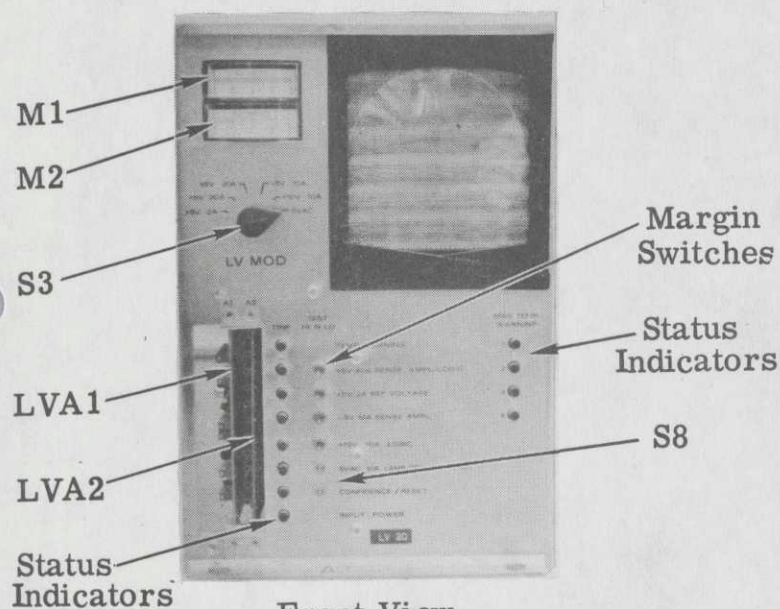
<u>REGULATOR (VOLTS)</u>	<u>CURRENT (AMPERES)</u>	<u>WHERE USED</u>
+4	2	Threshold voltage for sense amplifiers in magnetics modules.
+5	40	TTL logic voltage in core controller and sense amplifier voltage in magnetics modules.
-5	10	Sense amplifier voltage in magnetics modules.
+10	10	Floating switch voltage in magnetics modules.

The module circuitry is divided by function and located on various printed circuit boards (PWB's) or subassemblies. Table 5 tabulates these PWB's and subassemblies, and correlates their identification, description, and schematic drawing number.

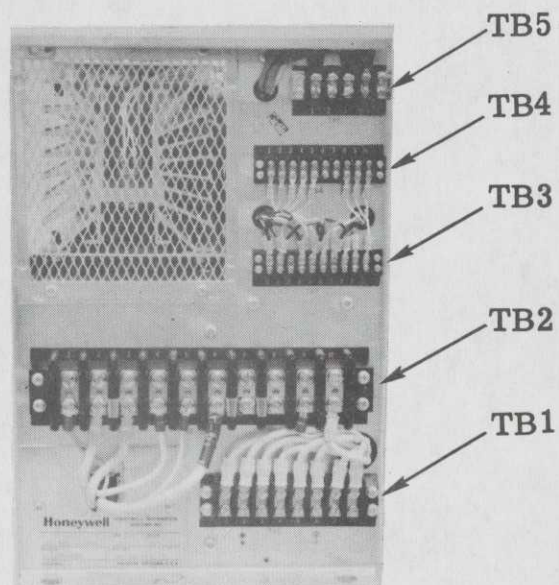
The LV regulator functional block diagram in Figure 9 shows how the PWB's and subassemblies fit into the regulators functionally. For the physical location of these PWB's and subassemblies refer to Figures 7a and 7b.



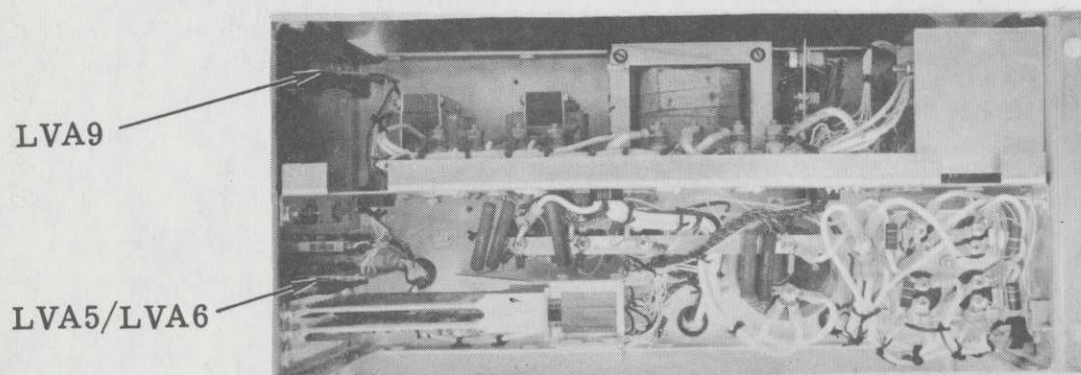
Top View



Front View

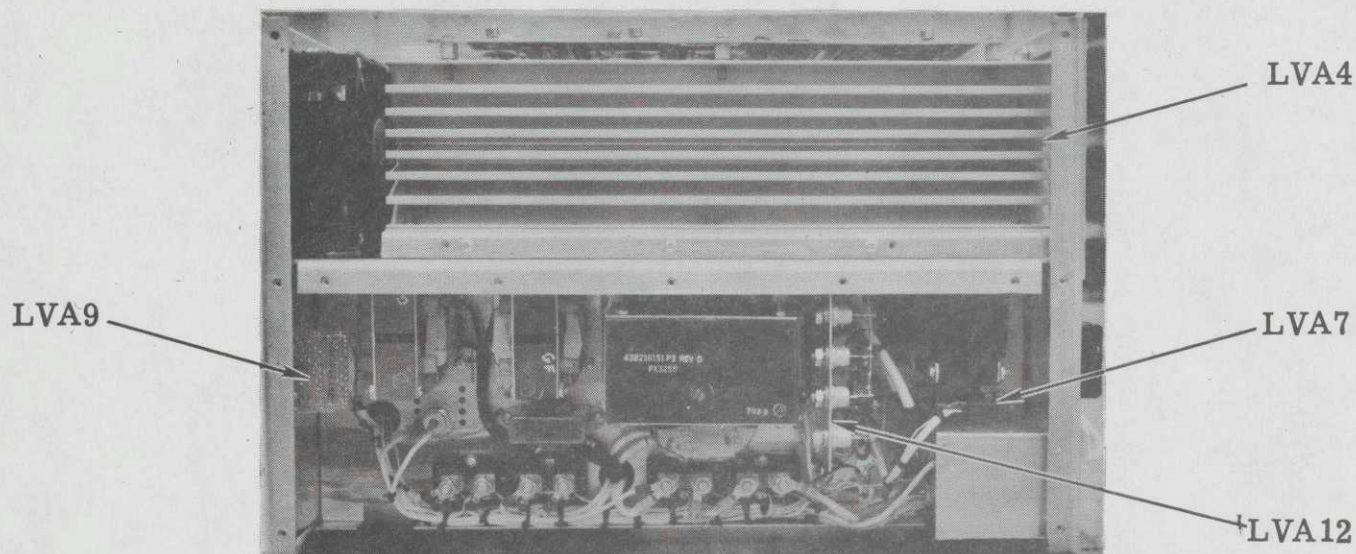


Back View

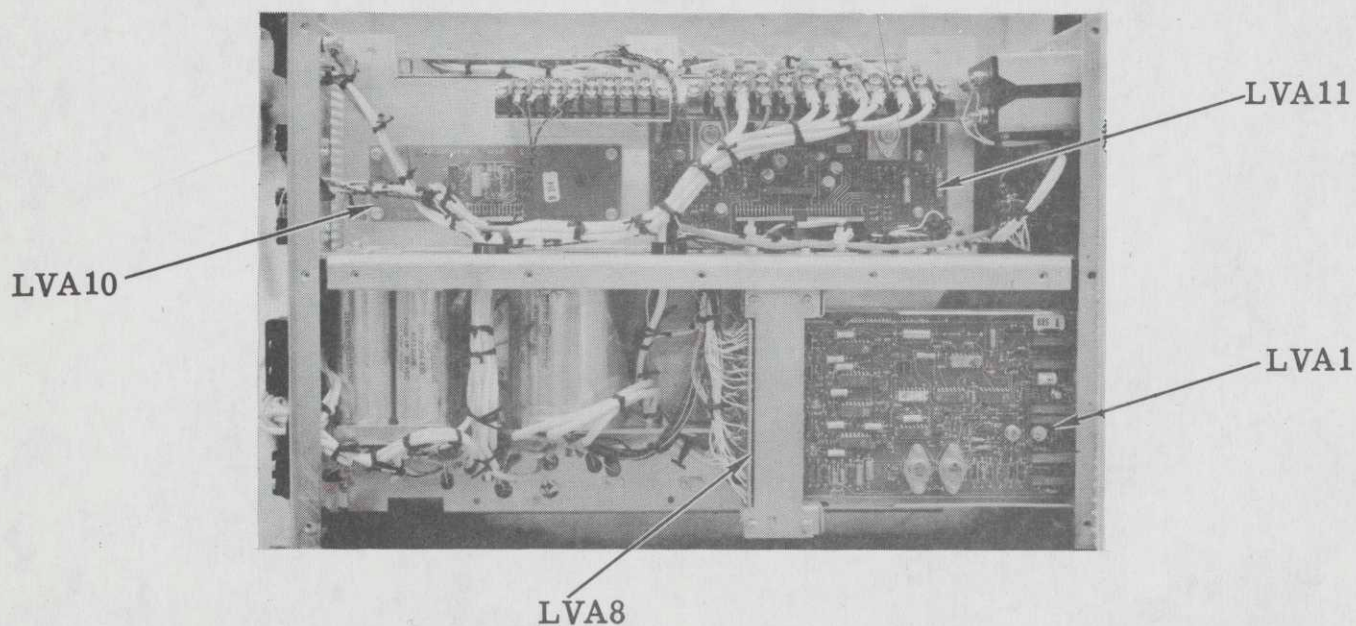


Bottom View

Figure 7a Low Voltage Module (A2)



Right Side View



Left Side View

Figure 7b Low Voltage Module (A2)

Table 5 - LV Module PWB's and Subassemblies

<u>IDENTIFICATION</u>	<u>DESCRIPTION</u>	<u>SCHEMATIC DRAWING</u>
LVA1	Regulator PWB	43D228545
LVA2	Confidence/Shutdown Control PWB	43D231941
LVA3	Driver PWB	43D222257
LVA4	Heat Sink Subassembly	-
LVA5	Multi-purpose Lamp Driver PWB	43C228027
LVA6	Multi-purpose Lamp Driver PWB	43C228027
LVA7	Lamp Power Control PWB	43C228065
LVA8	A1/A2 Backpanel PWB	-
LVA9	Multi-purpose Lamp Driver PWB	43C228027
LVA10	Temperature Warning Control PWB	43B227427
LVA11	Overvoltage Shutdown PWB	43D226616
LVA12	Crowbar Subassembly	43C220146

These ten PWB's and two subassemblies are all mounted on the module main frame. All but two PWB's are permanently mounted and can only be removed by taking the module out of the memory cabinet. The two exceptions are the LVA1 and LVA2 PWB's. They are plugged into the module through the front panel and can be replaced with the module still mounted in the memory cabinet. The LVA8 backpanel PWB is part of the connector subassembly used to interconnect the A1 and A2 pluggable PWB's.

The passing transistors for each of the four regulators are mounted on the A4 heat sink subassembly as are the temperature thermostats. The heat sink is cooled by the blower mounted in the module front panel. The filtering sections for each regulator are mounted on the main frame and consist of one choke, two filter capacitors, and one or two bleeder resistors per regulator. The metering circuitry also is mounted on the main frame. The LV main frame schematic (43D220576) shows the relationship between the passing section, filtering section and metering for all LV regulators.

2.4.2 Module Voltage Distribution (Internal)

D-C voltages to the LV module are supplied to the regulator passing transistors and operate the internal regulator circuitry. Figure 8 shows how the internal voltages are distributed in the module. Three unregulated d-c voltages from the TR, $\pm 15V$, and $+22V$, are used for the regulated output and internal voltages. The regulated output voltages are discussed in Section 2.4.3. Figure 8 shows all terminal board and printed circuit board connections. The A3 PWB uses the bulk voltages for the passing transistor drive circuitry. Six additional d-c voltages are developed and used internally: $+10V$, $+6V (V_{CC})$, $-6V (V_{EE})$, $+5V (V_{BB})$, $+5V$ reference, and $-5V$ reference. The $+10$ volts is developed on the A11 PWB to operate the overvoltage unijunctions. It is distributed to the A1 PWB. The ± 6 volts are used by all operational amplifiers. The $+5$ volts is used by all transistor transistor logic (TTL) and is developed from the $+6$ volts on the same PWB, except on the A10 PWB, which gets its $+5$ volts from A11. The A11 PWB develops its $+5$ volts from the $+10$ volts on the board. Both the ± 5 volts reference voltages are temperature compensated and are used to develop error signals to regulate the output voltages.

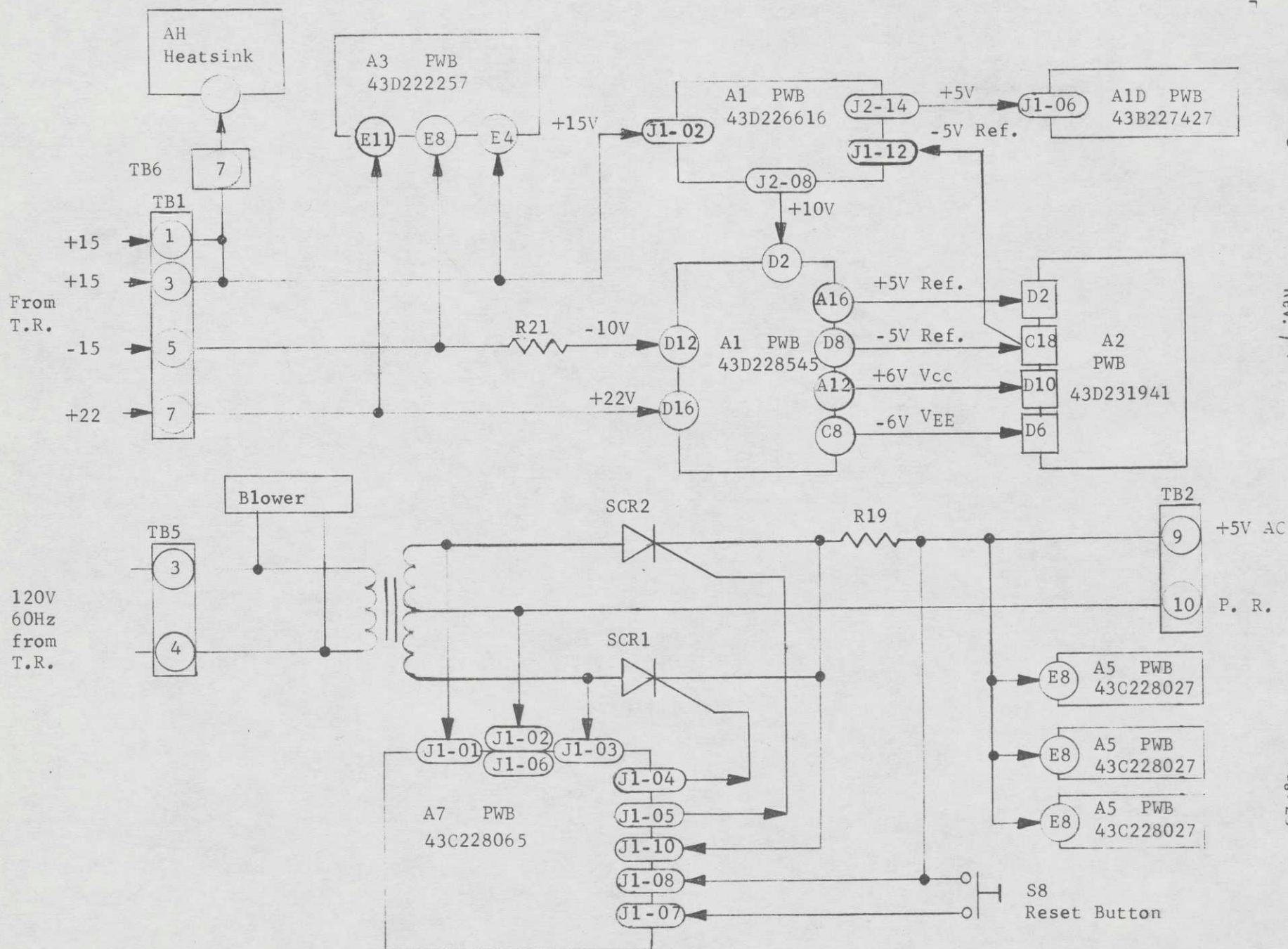


Figure 8. LV Internal Voltage Distribution

Honeywell

Rev. A

Page 23

43A177737

In addition to the above, the LV module uses 120 volts ac from the TR to operate the A4 heat sink blower and develop a +5 volts ac voltage for all lamp indicators in the memory cabinet. Figure 8 shows the +5 volts ac circuitry. A step down transformer and two rectifier SCR's are used to provide a 5 volts ac full-wave rectified voltage. The lamp circuitry that uses this voltage is discussed in Section 2.8.

The LVA7 controls the two SCR's. If an overcurrent load develops, a resistor, R19, detects the condition (approximately 10A) and fires an SCR on the LVA7 PWB, which removes the drive to the rectifier SCR's; thereby shutting the +5 volts off. A push-button, S8, on the front panel of the module restores the voltage. It momentarily shunts the holding current of the SCR triggered so that it can be turned off. If the overcurrent has been removed, the supply will operate.

2.4.3

Theory of Regulator Operation

A time-ratio control (TRC) technique is used for all four low voltage regulators. Since the theory of operation for these regulators is the same, only one typical regulator will be discussed in detail. The functions that are shared between regulators or unique to a given regulator will be discussed separately. Figure 9 is a functional block diagram of a LV regulator. The various blocks of this diagram can be grouped into two basic categories; those that are links of the basic control loop and those that are additional functions necessary to sequence and protect the basic control loop. The basic control loop and the two protection circuits are discussed in this section. The startup/turn-off sequencing and temperature control circuitry are discussed separately in Sections 2.6 and 2.7 since their operation involves other modules.

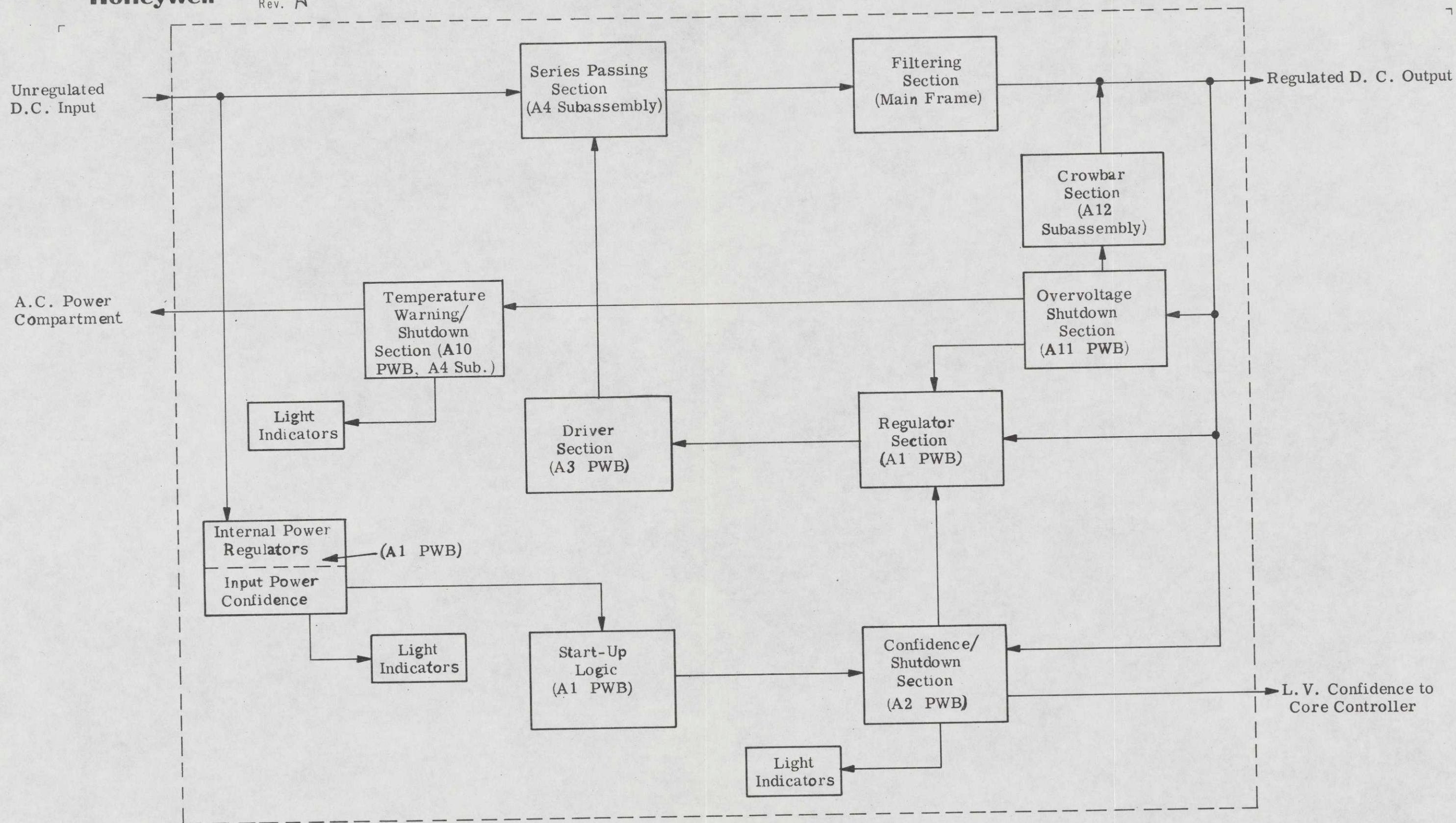


Figure 9. L. V. Regulator Functional Block Diagram

2.4.3.1 Basic Control Loop

There are four blocks on Figure 9 that make up the basic regulator control loop. They are: the Series Passing Section, the Filtering Section, the Regulator Section, and the Driver Section. The primary path of power flow is from the unregulated TR bulk voltages through the series passing and filtering sections to the output load.

Voltage regulation is accomplished by means of a feedback signal from the output of the module which tells the series pass section how much power to pass to maintain the output voltage.

The Series Passing Section consists of one passing transistor and is the heart of the regulator. By turning this transistor on and off, the power delivered by the regulator is controlled. An unregulated bulk voltage from the TR module is delivered to the passing transistor and is approximately twice the voltage of the desired regulator output voltage.

A time-ratio control method is used to regulate the output voltage. The transistor is operated at approximately a frequency of 2 kilohertz and the percentage of any given cycle that the transistor is on depends on the level of d-c voltage sensed at the output of the filtering section. The transistor on/off ratio is governed by the ratio of the regulated d-c output voltage to the unregulated d-c input voltage, i.e.,

$$V_{\text{out Regulated}} = \left(\frac{T_{(\text{on})}}{T_{(\text{on})} + T_{(\text{off})}} \right) V_{\text{in Unregulated}}$$

The passing transistor is located on the A4 heat sink and is cooled by the heat sink blower. Figure 10, which is an electrical schematic of the representative complete control loop, shows how this transistor fits into the overall loop.

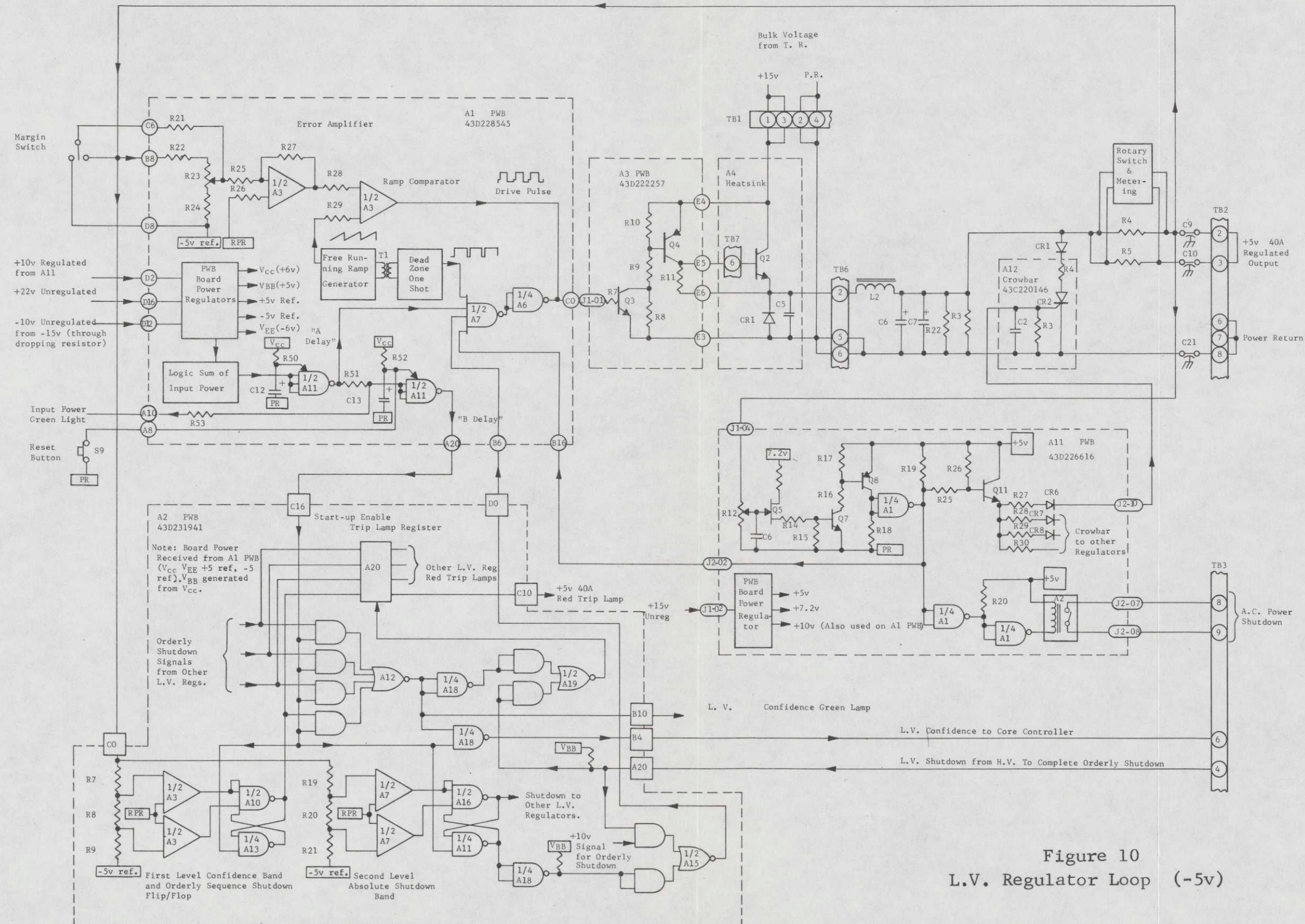


Figure 10
L.V. Regulator Loop (-5v)

The filter section consists of a commutating diode, a choke, two filter capacitors and two bleeder resistors. The purpose of the filter section is to convert the power pulses from the passing transistor into a constant voltage output. Components L2 and C6 of Figure 10 form the LC network that performs this function.

During the time that the passing transistor is on, the LC network stores energy and when the transistor turns off, this network delivers the necessary energy to maintain a relatively constant voltage. When the transistor is off, the commutating diode CR1 provides the current path necessary to maintain the output current. The filter section output voltage rises when the passing transistor is on and falls when it is off. This voltage change is called the regulator ripple and for all LV regulators is less than 50 millivolts.

The other capacitors of this section provide additional filtering and the bleeder resistors provide the preloading necessary to maintain proper regulation. From the output of the filter section, the regulated voltage is delivered out of the LV module.

The regulator section consists of a feedback sense line, a feedback reference divider, an error signal amplifier, a free-running ramp generator, a dead zone one-shot, and a ramp comparator. With the exception of the feedback sense line, all of these functions are performed on the LVA1 PWB as shown in Figure 10.

The purpose of the regulator section is to sense the output voltage and tell the passing transistor to turn on for the proper period of time to maintain the desired output voltage. The feedback signal is internally sensed at the output feed-through capacitor. This signal comes onto the LVA1 PWB and is fed into a divider. R23, the potentiometer in the divider, is used to adjust the regulator to the desired output voltage.

The divider is referenced at one end to the -5 volt reference supply and the regulator attempts to keep the potentiometer voltage on the wiper arm at zero volts. The voltage at this point is compared to the reference power return and any difference between the two is amplified by the inverting error amplifier. If the output voltage is slightly lower than the desired output, the error amplifier output will go in the positive direction and vice versa.

The next stage in the loop is an amplifier used as a comparator. It is called the "ramp comparator." A ramp is generated by a free-running oscillator running at approximately 2 kilohertz. The two inputs to the comparator are the ramp and feedback error signals. Figure 11 shows the amplitude and time relationship of these signals.

The purpose of the ramp comparator is to convert a voltage error signal into a pulse width that is dependent on the error signal. For the period of time in any cycle that the error signal to the comparator is greater than the ramp input, the comparator output will be at a logic one. For the period of time that the error signal is less than the ramp signal, the comparator output will be at -0.7 volt. Therefore, as the error signal becomes more positive, which indicates the output voltage is slightly lower than desired, the positive pulse out of the ramp comparator will be wider. It is this pulse width that ultimately tells the passing transistor how long to stay on. So the wider this pulse is, the longer the passing transistor stays on, until the output voltage has increased to the desired voltage.

The free-running oscillator used to generate the ramp is also used to trigger a one-shot that generates a dead zone. This dead zone occurs once each cycle and it guarantees that the passing transistor shuts off each cycle. This protects the transistor from being on continuously during a startup cycle (reference paragraph 2.6.1) when

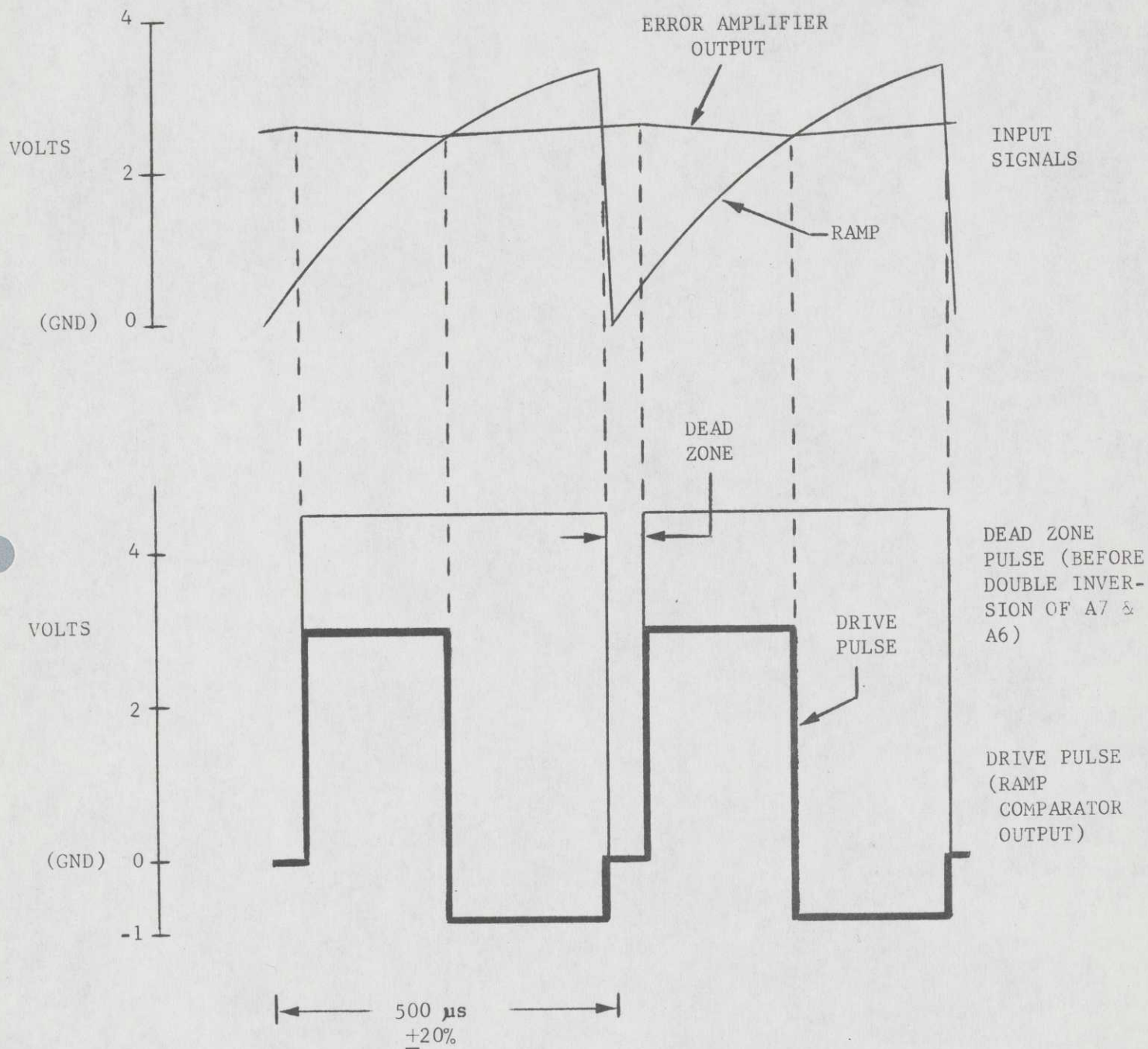


Figure 11. LV Ramp Comparator Signals

the pulse width will be at its maximum for many cycles. The dead zone is ANDed with the output of the ramp comparator to complete the development of what is called the "drive pulse." Figure 11 shows the time relationship of the signals used to make the drive pulse.

The Drive Section takes the drive pulse developed on the LVA1 PWB and turns the passing transistor on and off. Two transistor stages are used to boost the drive pulse capabilities. This circuitry is located on the LVA3 PWB.

2.4.3.2 Over/Undervoltage Confidence Circuitry

The primary protection for each of the LV regulators consists of confidence circuitry that establishes voltage bands around the regulated output voltages which are monitored at all times. If the output voltage passes through one of these bands, the regulator is considered to be out of regulation and a power down sequence is initiated to protect the regulator and the external circuitry.

The confidence circuitry is located on the LVA2 PWB and shown schematically on 43D231941. Each regulator is monitored by two sets of confidence bands. One is set to trip at $\pm 9\%$ and the other at $\pm 12\%$. The bands are established by two operational amplifiers used as comparators. If the output voltage goes above or below the band limit, the corresponding op amp output goes from a logic "1" to a logic "0." A latch stores the out-of-confidence information, while the power-down sequence is being performed.

The actions taken when the first band ($\pm 9\%$) is exceeded are: lighting of red trip indicator on module front panel corresponding with the regulator that faulted, and sending of a lack of confidence signal to the core controller to start an orderly shutdown. None of the LV regulators are powered down by this occurrence; however, when the orderly shutdown started by the lack of LV confidence

has reached the HV modules and they are both powered down, a signal is returned to the LV module telling it to power down.

The second band ($\pm 12\%$) exists to protect the LV regulators in case the orderly shutdown signal from the HV modules fails to be received by the LV module and the faulting regulator continues to deviate from normal. If the +5V regulator voltage passes through the second band, all LV regulators are immediately powered down. If any of the other three LV regulator voltages, +4V, +10V or -5V, pass through the second band, all of these regulators are immediately powered down, but the +5V regulator is left up. Latches also are used on the second band operational amplifier outputs to store the fault information while shutdown action is being taken.

The confidence bands on the +4V regulator are adjustable up or down with potentiometer R26 on the LVA2 PWB. If the output voltage is being adjusted to an unusual positive or negative reference voltage, these confidence bands must be simultaneously adjusted in the same direction to keep the bands evenly positioned around the output voltage.

2.4.3.3 Overvoltage/Crowbar Circuitry

There is present in the LV module another level of overvoltage protection called the "overvoltage/crowbar." This circuitry protects the memory cabinet circuitry in the event that either the LVA2 overvoltage circuitry has failed to power down the faulting regulator, or the passing transistor has shorted and cannot be turned off. Since damage to the memory circuitry due to an overvoltage in a LV regulator can be excessive, this additional level of shutdown protection has been incorporated.

The overvoltage sensing circuitry is located on the LV A11 PWB and is shown schematically on 43D226616. The crowbar circuitry is located on the LV A12 PWB and is shown schematically on 43C220146. Figure 10 shows how both of these functions fit into the overall control loop.

The output voltage is sensed and delivered to the LV A11 PWB. If this voltage exceeds the limits as shown in Table 6, a unijunction transistor triggers the shutdown action. Three steps are taken to ensure a complete and non-destructive shutdown: the drive pulse is dropped to a logic "0" via the LV A1 PWB, the crowbar SCR is fired which pulls the output voltage towards ground, and the a-c breaker in the A-C Power Compartment is opened removing power from the TR module. An overvoltage in any of the regulators initiates this same action.

Table 6 - Overvoltage/Crowbar Limits

<u>REGULATOR</u>	<u>OVERVOLTAGE LIMIT</u>
+4V	+6.0V
+5V	+7.0V
+10V	+12.0V
-5V	-7.5V

The method for sensing an overvoltage on the -5V regulator is different than the other three regulators shown on 43D226616. The -5V reference voltage is used to provide a negative trip level. It is also necessary to disable this sense circuitry during the startup cycle because of the order in which the internal PWB power to run this sensing circuit comes up. The A Delay signal is used to disable this circuit until all board power is guaranteed operational. A discussion of the startup timing is found in paragraph 2.6.1.

In Figure 10 a diode CR1 is shown above the crowbar SCR. This diode is present only in the +5V regulator. Its purpose is to guarantee that the crowbar SCR if fired during the startup cycle, will turn off. A residual voltage exists on the output of the +5V, 40A regulator even when the memory cabinet is completely powered down. The power supply in the System Controller provides current through the interface lines that develops a residual voltage of approximately 0.6V on the +5V regulator output. During the regulator startup cycle it is possible because of the way the LVA11 board power comes up to momentarily gate the crowbar SCR on. The 0.6V residual voltage is sufficient to hold the SCR on and the regulator will try to come up into a crowbarred output. But, the diode CR1 guarantees that the voltage across the SCR will be insufficient to keep the SCR on and it turns off.

2.4.4 Panel Controls

On the front panel of the module, controls are provided for the monitoring and adjusting of the regulator's operation. The controls are the metering/rotary switch, the voltage adjustment potentiometers, the margin switches, the regulator status indicators, the magnetics temperature warning indicators, and the reset buttons.

2.4.4.1 Metering/Rotary Switch

The voltage and current status of any of the LV regulator (including the +5V AC) can be monitored. A voltmeter, M1, an ammeter, M2, and a rotary regulator selector switch, S3, are on the LV front panel. The rotary switch is rotated to the desired regulator and the voltage and current of that regulator will be displayed on the meters. The meters provide a readily available output monitor for use as an aid in checking the operation of the regulators or in isolating problem areas when troubleshooting the power system. These meters, however, are not of sufficient accuracy to set the regulator voltages.

The electrical connections for the rotary switch, voltmeter, ammeter, and meter shunts are shown on the main frame electrical schematic, 43D220576. As shown, the +5V 40A regulator metering is divided into two +5V, 20A readings. The total current demand on this regulator is the sum of the separate current readings. The +5V AC voltage meter reading will be the average voltage and will normally be somewhat less than the +5V (approximately 4.4 volts).

2.4.4.2 Voltage Adjustment Potentiometers

The four LV regulators are set by adjusting four potentiometers on the LVA1 PWB. To gain access to these potentiometers, the metal PWB cover on the LV front panel must be removed. The LVA1 PWB is on the left-hand side. The top four potentiometers on this PWB are for regulator adjustment, while the bottom two are used to set the +5V internal reference voltages. Figure 12 identifies and shows their location.

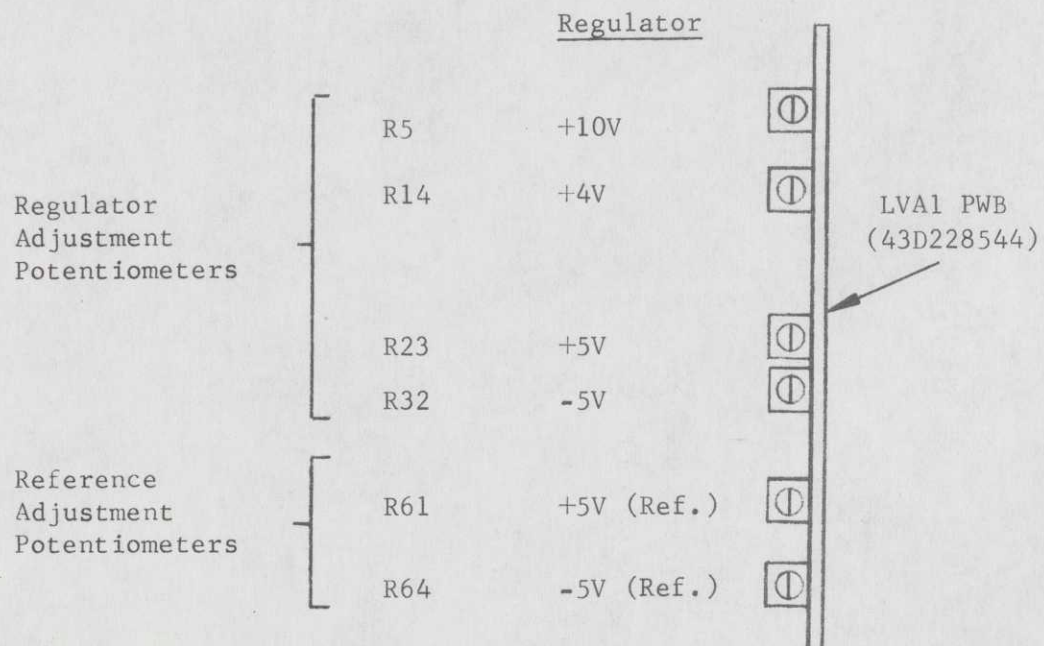


Figure 12 - LVA1 Potentiometer Locations

A discussion of how the regulator adjustment potentiometer fits into the regulator control loop is found in paragraph 2.4.3.1.

The reference adjustment potentiometers are adjustments ordinarily made only in the factory where precision test equipment is available. If adjustment is to be made to these references voltages, it is necessary to go onto the PWB to monitor the voltage. These voltages are available at capacitors C5 and C6 on the LVA2 PWB as shown in 43D231941. They should both be within 0.1% of $\pm 5V$.

2.4.4.3 Margin Switches

In the center of the front panel are located four double throw toggle switches which permit operation of the four LV regulators at $\pm 5\%$ of their nominal value. The margining is accomplished by switching in a parallel resistor across either the positive or negative half of the feedback divider located on the LVA1 PWB. Figure 10 shows schematically how switching the margin switch shunts half of the divider with a resistor causing the control loop to find a new equilibrium level. The new level is either a plus 5% or a minus 5% of the original setting.

2.4.4.4 Status Indicators

Just left of the margin switches are a row of indicator lamps which report the operating status of the four LV regulators at all times. These indicators are discussed in the order (from top to bottom) they appear on the front panel of the LV module.

Temperature Warning - A red light turns on to indicate that a first level temperature warning exists. A complete discussion of the method of temperature control is found in Section 2.7.

Trip Indicators - The next four red lights (one for each regulator) turn on when an over or under-voltage fault has been sensed. Only the light associated with the faulting regulator will turn on, thereby isolating the bad regulator.

A discussion of how an over/undervoltage fault is sensed and stored is found in Section 2.4.3.2.

5V AC Lamp Driver - A green light turns on when the +5V AC lamp driver voltage is on. Whenever the main contactor is closed providing a-c power to the supply, this light will be on.

Confidence - A green light turns on when all four LV regulators are within their confidence bands (+9%). This light is also controlled by the LV B Delay as shown in Figure 18. The B Delay must have timed out before the confidence light will come on. This light turns off whenever a lack of LV confidence is sent to the core controller.

Input Power - A green light turns on only if all input voltages (+15V, -15V, and +22V) are present to the LV module. Since it is driven by the A Delay signal, it is turned on approximately 75 milliseconds after the input power is available.

The normal operation of the module is indicated by all red lights being off and all green lights being on. All of these indicator lamps are located on the A5 and A6 PWB's.

2.4.4.5 Magnetics Temperature Warning Indicators

Four red lights are present on the right-hand side of the LV module front panel. They are located on LVA9. These lights are independent of the LV regulators and are only used to display the temperature warning status of the four magnetics modules.

A red light turns on whenever an above normal temperature warning exists in one of the magnetics modules. To correlate a warning light with the magnetics module, refer to the Maintenance Procedure and Aids document, PM routine 6.6. Section 2.7.1 further discusses the temperature warning circuitry.

2.4.4.6 Reset Buttons

Two reset pushbuttons are provided on the front panel. The top one is used to reset the +5V AC lamp supply when it has tripped down due to an overcurrent condition. The second pushbutton is used to reset the LV regulators when one of them has tripped down. This reset when depressed restarts the B Delay to allow the regulators to come up. However, if a shutdown occurs in the memory cabinet that has caused the HV shutdown line to the LV module (Figure 18) to go to a logic "1," the reset button will not restart the supply. Refer to section of 2.6 for a complete discussion of the power ON/OFF sequence.

2.5 HIGH VOLTAGE MODULE (43D222280G2)

2.5.1 General Description

The high voltage module contains five high voltage regulators, two word regulators, two bit regulators and one distributed transformer (DT) regulator. The rating of each is summarized in Table 7.

Table 7 - Regulator Outputs

<u>REGULATOR</u>	<u>VOLTAGE (VOLTS)</u>	<u>CURRENT (AMPERES)</u>
Word #1	24 - 38	2
Word #2	24 - 38	2
Bit #1	24 - 38	20
Bit #2	24 - 38	20
DT	32	2

A detailed specification of each regulator can be found in Appendix 5.1.

The module is divided into various parts that are either printed circuit boards (PWB's) or subassemblies. These are tabulated in Table 7. The table also identifies the designation associated with each. For the physical location of these PWB's and subassemblies refer to Figures 13a and 13b.

Table 8 - Module PWB's & Subassemblies

<u>IDENTIFICATION</u>	<u>DESCRIPTION</u>	<u>SCHEMATIC DRAWING NO.</u>
HVA1	Regulator PWB	43A228555
HVA2	Confidence/Shutdown Control PWB	43A228560
HVA3	Driver/Overcurrent Cir- cuitry PWB	43D220591
HVA4	Heat Sink Subassembly	-
HVA5	Multipurpose Driver PWB	43C228027
HVA6	Multipurpose Driver PWB	43C228027
HVA7	Multipurpose Driver PWB	43C228027
HVA8	A1/A2 PWB Backpanel PWB	-
HVA9	Zener/Choke Subassembly	43C233547
HVA10	Crowbar Subassembly	43D233546
HVA11	Overvoltage/Sequence Circuitry PWB	43D233052

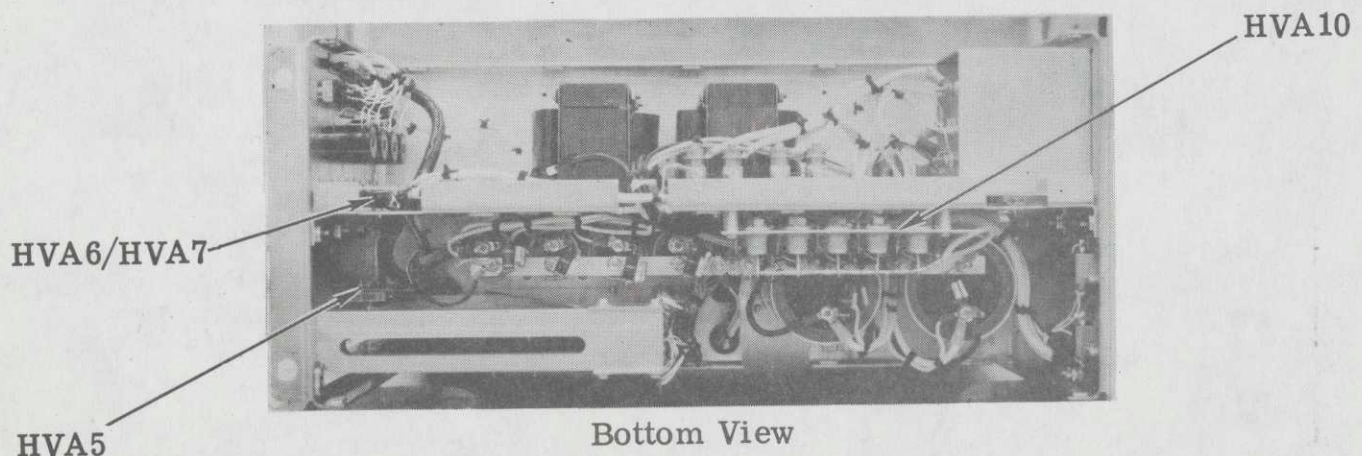
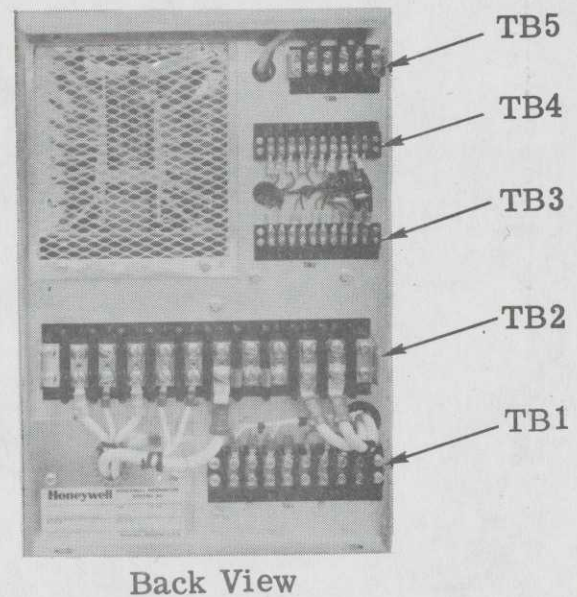
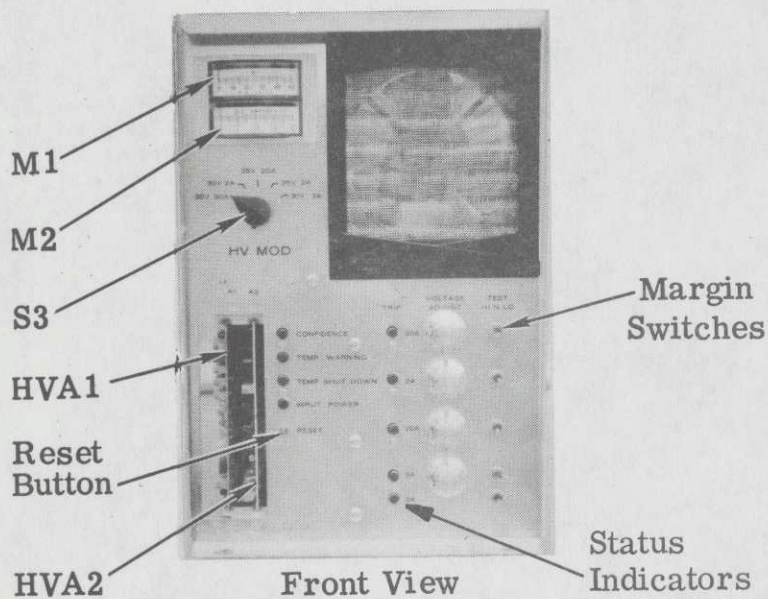
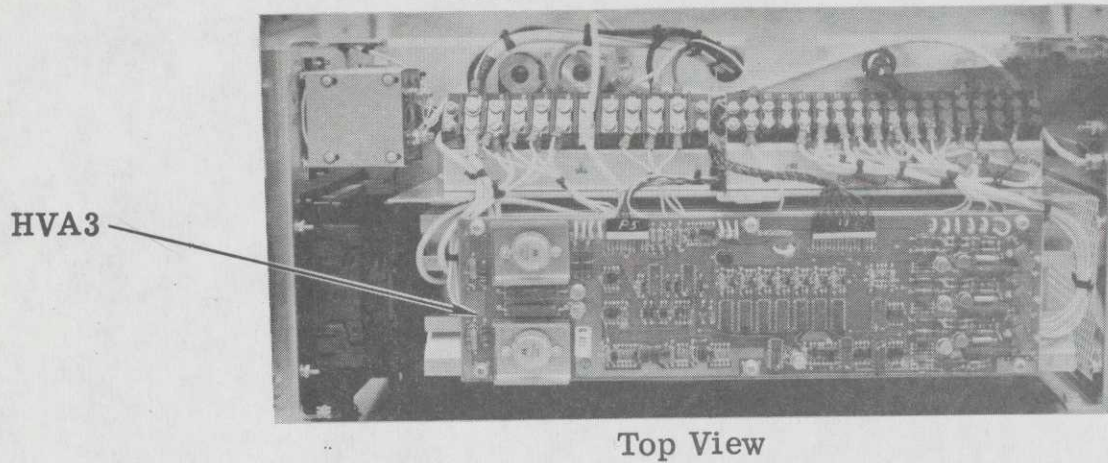
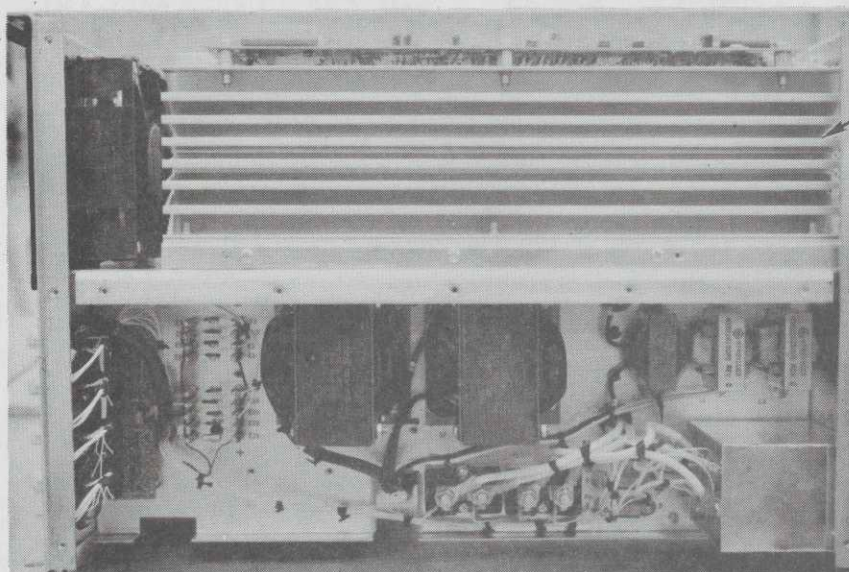


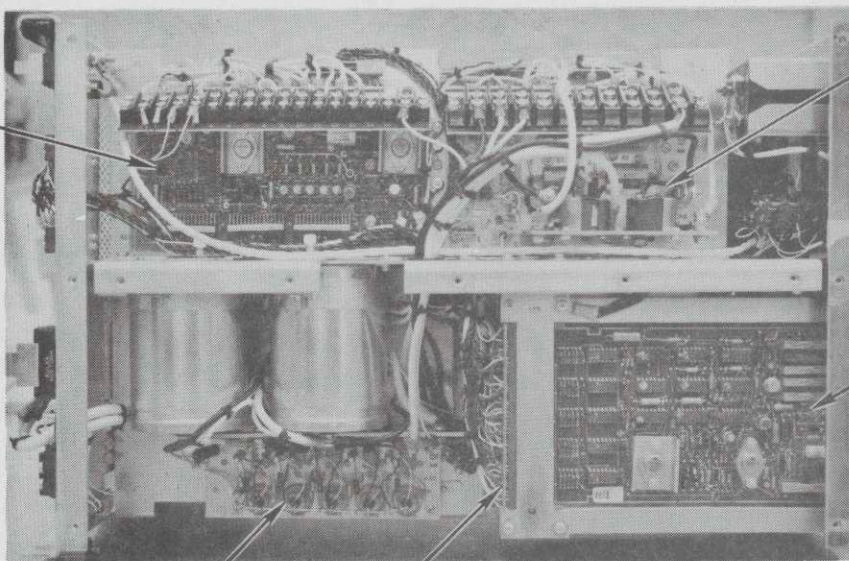
Figure 13a High Voltage Module (A3/A4)



HVA4

Right Side View

HVA11



HVA9

HVA1

HVA10

HVA8

Left Side View

Figure 13b High Voltage Module (A3/A4)

The module contains eight printed circuit boards and three subassemblies, all mounted on a main frame. Two of the PWB's (A1 and A2) are plugged into connectors and are removable, while the module is mounted in a cabinet. The remaining PWB's (A3, A5, A6, A7, A8, and A11) and subassemblies (A4, A9 and A10) are permanently mounted. These can only be removed by taking the module out of the cabinet. The PWB backpanel (HVA8) is a part of the connector subassembly used to interconnect the A1 and A2 pluggable PWB's.

The chokes, filter capacitors, metering circuitry, and remaining electronic components are mounted on the main frame.

The passing transistors for each of the five regulators are all mounted on the heat sink (A4). Emitter resistors for each high current regulator, as well as the temperature thermostats, are also mounted here.

2.5.2

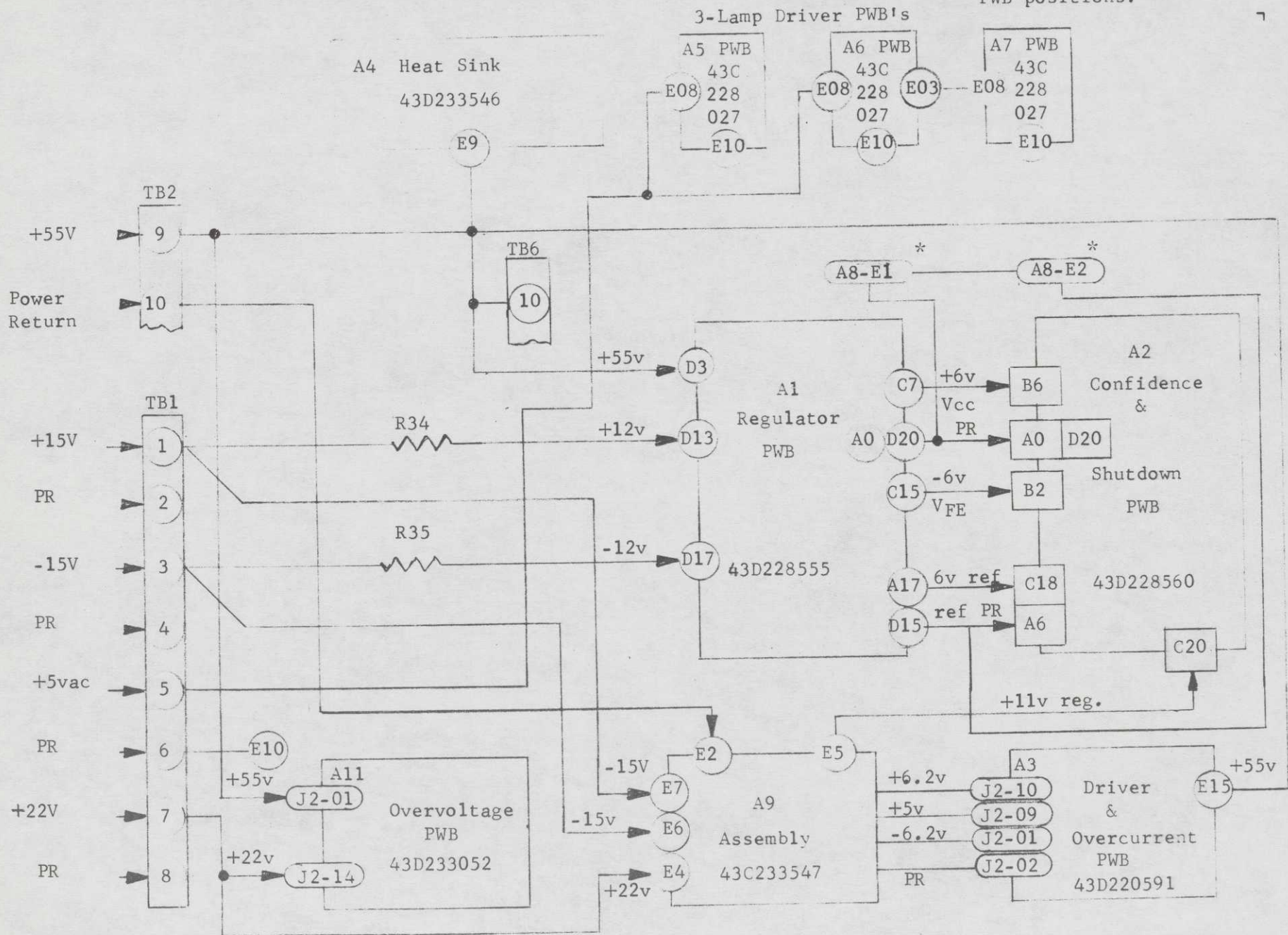
Module Voltage Distribution (Internal)

D-C voltages to the HV module are supplied to the regulator passing transistors and operate the internal regulator circuitry. Figure 14 shows how the voltages are distributed in the module. Four unregulated d-c voltages from the TR, $\pm 15V$, $+22V$ and $+55V$ are used for the internal voltages; only the $+55V$ is used for the regulated output voltages. The regulated output voltages are discussed in Section 2.5.3. Figure 14 also shows all terminal and printed circuit board connections.

Five d-c voltages are developed and used internally; $+11V$, $+6V$ (V_{CC}), $-6V$ (V_{EE}), $+5V$ (V_{BB}), and $+6V$ reference.

The $+11V$ is developed on the A9 subassembly and distributed to the buffer amplifiers on HVA2. The $\pm 6V$ is generated on HVA1 and used by all operational amplifiers. The $+5V$ used by all transistor transistor logic (TTL) is developed from the $+6V$ on those PWB's that require it. However,

*NOTE: Busses, located on A8
PWB between A1 & A2
PWB positions.



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Rev. A

Page 43

43A177737

Figure 14. H.V. Internal Voltage Distribution

the +6V and +5V required on HVA3 is obtained from the HVA9 subassembly. The +6V reference is temperature compensated and is developed on HVA1.

The HV module also uses +5V AC on the lamp indicators, PWB's HVA5, A6, and A7. This voltage is developed in the LV module and Section 2.4.2 explains how the voltage is derived.

2.5.3 Theory of Regulator Operation

A time-ratio control (TRC) technique is used for all five high voltage regulators. Since the theory of operation is the same for all, only one typical regulator will be discussed in detail. Those functions that are shared between regulators, or are unique to one, will be discussed separately.

Figure 15 is a block diagram illustrating the functional blocks of one regulator. These can be grouped into two categories; those that are links of the control loop and those that are necessary to sequence and protect the regulators. The basic control loop and the three protection circuits are discussed in this section. The startup/turn-off sequencing and temperature control circuitry are discussed separately in Sections 2.6 and 2.7, since their operation involves other modules.

An regulated d-c input voltage is provided by the transformer-rectifier module (A2). This voltage is applied to a series passing section that is either turned on or turned off, depending on the level of the d-c voltage sensed at the output of the filter section. The length of time the passing section is on or off is governed by ratio of the d-c output to input voltage which can be expressed as,

$$V_{\text{out}} \text{ (regulated)} = \left(\frac{t_{\text{on}}}{t_{\text{on}} + t_{\text{off}}} \right) V_{\text{in}} \text{ (unregulated)}.$$

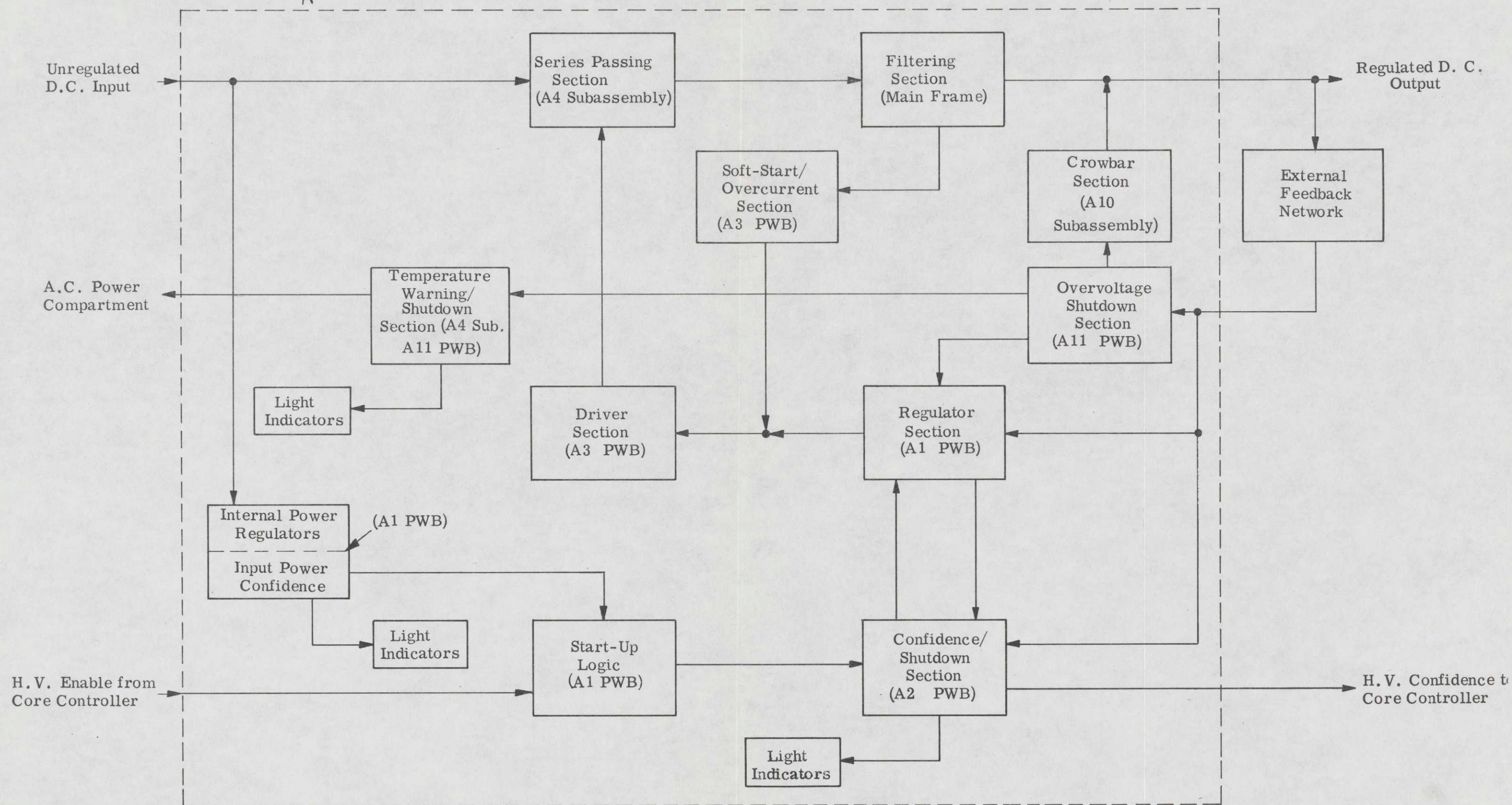


Figure 15 H.V. Regulator Functional Block Diagram

2.5.3.1 Basic Control Loop

The basic control loop consists of five blocks illustrated in Figure 15; (1) a series passing section, (2) a filter section, (3) a regulator section, (4) a driver section, and (5) a feedback network. Referring to Figure 16, each section is illustrated in detail. The primary path of power flow is from the unregulated TR bulk voltages through the series passing and filtering section to the output load. Voltage regulation is accomplished by a feedback signal from the output of the module, which tells the series passing section how much power to deliver to the output load. The time-ratio control technique determines how much power to deliver by turning the passing transistors on and off in proportion to the input bulk and regulated output voltages. For example, if the derived output voltage is 30 volts and the bulk is 50 volts, the on-time, t_{on} , would be approximately 60 percent.

The percentage on-time is derived by comparing two signals, an error signal from the output regulated voltage and a sawtooth ramp generated by a free-running unijunction transistor oscillator (UJT).

The series passing section consists of two transistors connected in parallel in a common collector configuration. They are switched at approximately a 2 kilohertz rate. Balanced drive is achieved by emitter resistors, R39 and R40. The transistors are located on HVA4 heat sink and cooled by a fan mounted on the front panel.

The filter section consists of a commutation diode, CR6, a choke, L5, filter capacitors, C20, C21 and C22, and a bleeder resistor, R9. The switched output of the passing transistors is connected to the filter section through a rate-of-rise choke, L2, recovery diode, CR10, and isolation diode, CR8. These component parts are located on HVA9. The

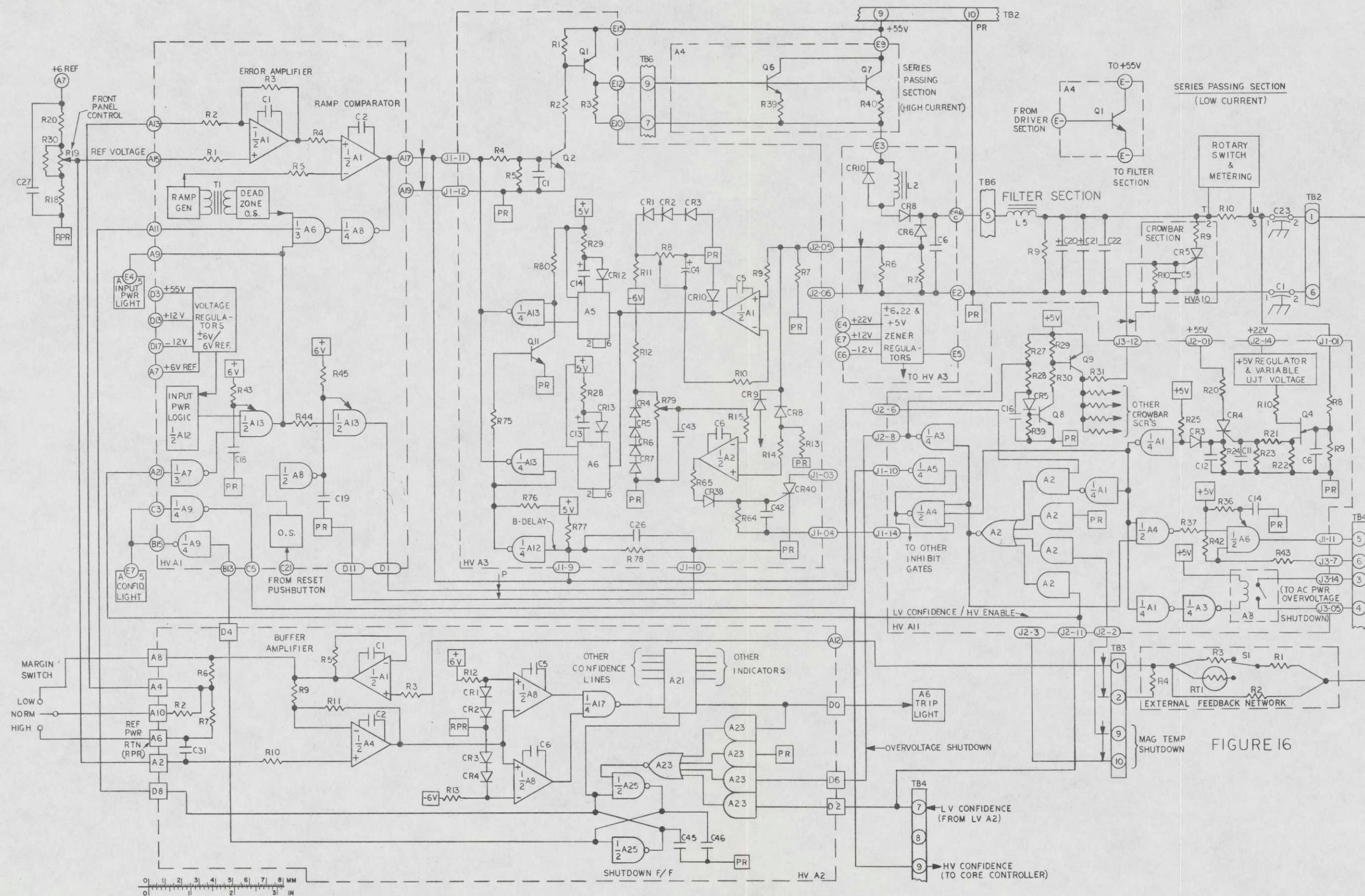


Figure 16 HV Regulator Loop (Bit #1)

purpose of the filter section is to convert the power pulses from the passing transistor into a constant voltage output. When the transistor is on the commutating diode CR6 is back biased, causing the current to flow into the choke. At the time the transistors turn off, the diode clamps to ground and maintains a return path for the choke current to the output load. The additional capacitors provide filtering by reducing the switching noise transients. The filter section maintains an output voltage ripple of less than 250 millivolts peak-to-peak.

The regulator section consists of (1) a feedback reference divider, (2) an error amplifier, (3) a free-running ramp generator, (4) a dead zone one-shot, and (5) a ramp comparator. All of these functions are performed on the HVA1 and A2 PWB's as shown in Figure 16. The regulator section senses the output voltage and tells the passing transistor to turn on or off at the proper times to maintain the desired output voltage.

Energy supplied to the LC network each time the passing transistor is turned on causes the output voltage to rise. When the passing section is turned off, the energy stored in the filter section is supplied to the load and the output voltage falls. This change in the output voltage is the error signal that is sensed, amplified and compared to the ramp generator. The ramp generator converts this error voltage into a time varying pulse, whose duration is proportional to the ratio of the bulk and regulated output voltages.

The UJT oscillator, Q3, is located on HVA1 and nominally has a period of 425 microseconds ($\pm 15\%$), where the ramp developed across C20 is reset in about 10 microseconds, each time the UJT triggers. Emitter follower, Q2, buffers the oscillator output and distributes a low impedance signal to one side of each ramp comparator (A1).

The output voltage is sensed by the temperature compensated feedback network located in the magnetics module and divided down by 6:1. This error voltage is buffered by an operational amplifier located on HVA2 and divided by two again, before it is applied to the input of the error amplifier located on HVA1. The error signal is then amplified and fed to the ramp comparator.

The output state of the comparator is determined by the relationship between the instantaneous voltage of the ramp and the level of the feedback error voltage. At the start of each oscillator period the ramp voltage begins at ground potential and increases to approximately two volts. At some point in the period, however, the ramp voltage exceeds the output level of the error amplifier. Prior to reaching this point the output of the comparator is at two volts. But, as the ramp voltage passes through the potential established by the error amplifier, the output switches to approximately -0.8 volt. This signal is supplied to the driver section located on HVA3.

Figure 17 illustrates the time relationships between each of these important signals. V_r (ramp) is the output signal of the ramp generator; V_e (error) is the error ripple voltage detected across the output filter capacitor, C20 on the main frame; and V_p (pulse) is the output voltage of the ramp comparator, A1 on HVA1. The pulse, V_p , ultimately tells the passing transistor how long to stay on. So the wider this pulse is, the longer the passing transistor stays on and the higher the output voltage.

The free-running oscillator that is used to generate the ramp also is used to trigger a one-shot that generates a dead zone, illustrated in Figure 17. This dead zone occurs once each cycle and guarantees that the passing transistor shuts off each cycle. This protects the transistors from being on continuously during a startup cycle when the pulse width will be at its maximum. The dead zone is ANDed with the output of the ramp comparator to form the drive pulse.

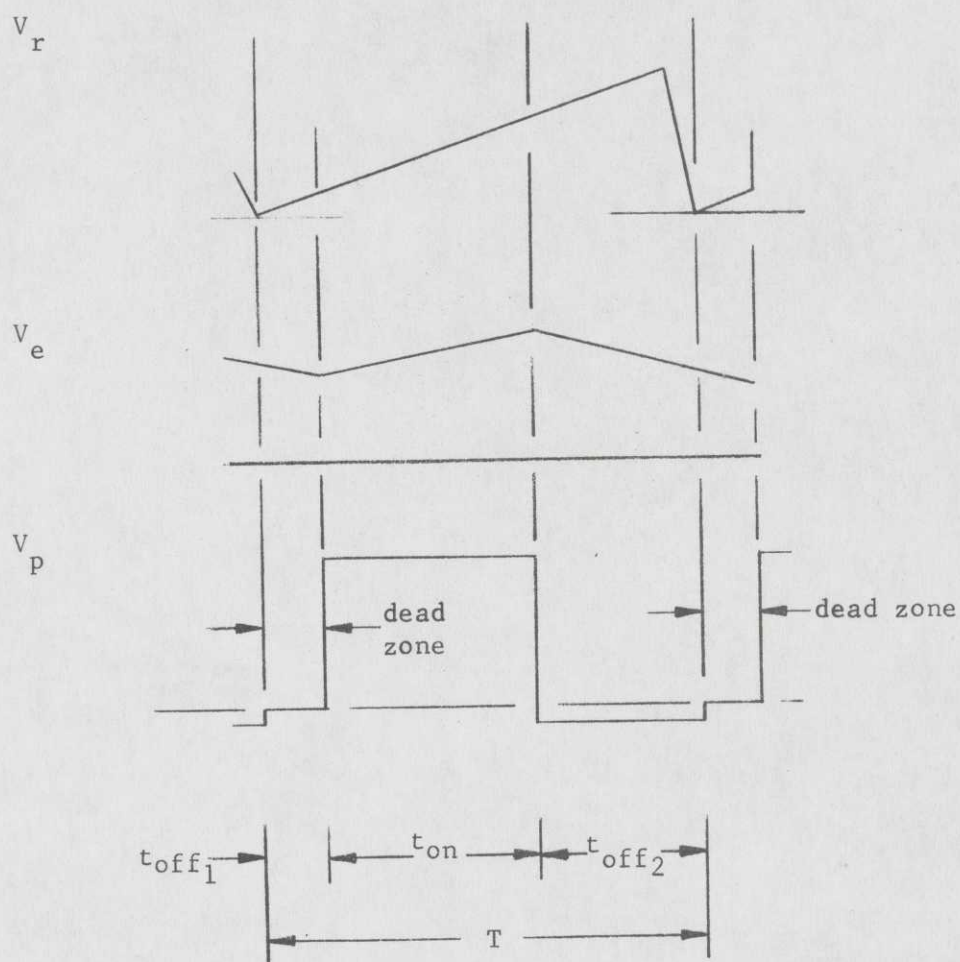


Figure 17 - HV Ramp Comparator Signals

The driver section takes the drive pulse developed on the HVA1 PWB and turns the passing transistors on and off. Two inverter stages provide the drive to the passing section. This circuitry is located on HVA3.

Recognize the differences between the high current (20 amperes) passing section, Q₆ and Q₇, and the low current (2 amperes), Q₁. This is, the low current regulator has only one passing transistor, Q₁, and no rate-of-rise limiting choke as does the high current section (CR9 and L1). They are similar functionally in every other respect, except for some of the actual component values.

There is one other difference. The feedback network for the DT regulator is not located in the magnetics modules as are the word and bit. It is located on HVA1 and adjustable using R58, which is accessible from the front of the module when it is in the cabinet.

2.5.3.2 Over/Undervoltage Confidence Circuitry

All of the circuitry necessary to detect an over or undervoltage condition at the output of a regulator is located on HVA2.

The output voltage of the buffer amplifier, A1, referenced in Figure 12, is sensed and compared to the voltage set on the front panel control, R19. The resistors R9, R10, and R11 cause the output of the summing amplifier, A4, to be at zero potential whenever the output voltage is within the confidence band. The wiper arm of R19 is the reference for positioning the confidence band, which tracks the output voltage over the 24V to 38V range of adjustment. The confidence band is determined by the positive and negative voltages developed across diodes CR1, CR2, CR3, and CR4. Comparing the reference voltages across the diode networks with the output of the summing amplifier, A4, permits the under/overvoltage comparators, A8, to determine confidence. One half of comparator A8, with the

compensation capacitor C5 is used to detect an undervoltage condition while the other half detects an overvoltage.

As long as the output of the regulator is in confidence, the outputs of A8 will be high. The high logic levels into A17 provide a logic zero output to a 4 bit storage register, A21. In the event of a lack of confidence, two logical operations occur, (1) the regulator that has faulted is identified on the front panel by lighting a red trip light, and (2) the shutdown flip-flop, A25, is tripped.

Tripping the flip-flop initiates three additional actions, (1) removes drive from the passing section through logic gates A6 and A8 on HVA1, (2) latches a flip-flop register in A21 so that status can be stored, and (3) logically signals the Core Controller, through logic gates A9 on HVA1, that confidence has been lost. Other conditions that cause the shutdown flip-flop to operation are more thoroughly discussed in Section 2.6.

2.5.3.3 Overvoltage/Crowbar Circuitry

Overvoltage protection circuitry is provided at each regulated output. It is located on HVA10 and HVA11. The crowbar subassembly, HVA10, contains the SCR crowbar networks, while HVA11 has the detection, logic, and SCR drive circuitry. The primary function of this circuitry is to lower the output voltages to the magnetics module long enough for the main power to be removed.

When an output exceeds +40 volts, regardless of the cause, this circuitry initiates (1) crowbar action by shorting each regulated output, (2) toggles the shutdown flip-flop, A25, (explained partially in Section 2.5.2.3), (3) removes the drive from each passing section, (4) logically initiates a shutdown cycle to the low voltage module, and (5) removes a-c power to the cabinet by dropping out the main contactor, K5, in the A-C Power Compartment.

A precision divider, R8 and R9 on HVA11, senses the output voltage as shown in Figure 12. This voltage is applied to the emitter of a UJT, Q4, whose trigger level has been set by adjusting its base #2 voltage using R44.

Once the sensed voltage exceeds the trigger level of Q4, the SCR, CR4, is fired. Logic gates A1, A2, and A3 enable the crowbar SCR drive transistor, Q9. However, C16 delays the turn-on of the SCR's approximately 150 microseconds to allow the drive to the passing transistors to be removed and toggle the shutdown flip-flop first. Gates A4 and A5 logically turn-off the drive inverter, Q2 located on HVA3, by clamping the drive signal from the ramp comparator, A1 on HVA1. Since the output of A5 is an open collector, just as A8 is on HVA1, it is possible to form a "wired OR" function at the output of A1.

The critical shutdown path is through logic gates A1 and A3 on HVA11. Once A3 turns on, the transfer pair contacts of A8 must close and ground the relay coil of K2, the power-off relay in the A-C Power Compartment. This accomplished, all power to the cabinet will have been removed by dropping out the main a-c contactor.

A shutdown signal to the low voltage module is also initiated, but it is dependent on the status of the other high voltage module. When overvoltage occurs, a logic "1" is applied to A6 on HVA11. The output of A6, however, is dependent on the logic level at TB4-6. If the fault occurred in the HVA4 module, there is no input signal at TB4-6, and the pull-up resistor, R42, causes the A6 output to go high, 180 microseconds after the fault. Should the fault have occurred in the HVA3 module, then the state of A6 depends on HVA4. Since this logic is required only for the shutdown sequence, explained in Section 2.6, it is very likely that HVA4 is operating properly and supplying a logic "0" to TB4-7. Consequently, the output of A6 will remain at logic "0."

2.5.3.4 Softstart/Overcurrent Circuitry

The overcurrent circuitry for the high and low current regulators is located on HVA3. Only the sense resistors, R4 through R7, for the two high current regulators are located on HVA9.

Three basic functions are performed by this circuitry, (1) an overcurrent condition causes all regulators to be turned off, (2) the passing transistors are current limited during the start-up power sequence, and (3) a second redundant overcurrent level turns off all regulators in the event current limiting is defective.

Current sense resistors, R6 and R7, illustrated in Figure 12, are connected in series with the commutating diode CR6. Each time the passing transistors are turned off, the negative voltage developed across these resistors is sensed by the current comparator, A1, and overcurrent shutdown comparator, A2. The threshold levels for these operational amplifiers are set by R8 and R79, respectively. Whenever the threshold for A2 is reached, A1 switches to a low logic level and triggers the monostable one-shots, A5 and A6.

Before the monostables are triggered, these outputs are in the logic zero states. Since the outputs of A13 are collected OR'd with the ramp comparator, and the output transistors of A13 are off, control of Q2 is not inhibited. Consequently, the ramp comparator controls Q2 and the loop is in regulation.

Triggering the monostables causes their outputs to switch to a high logic state and attempts to turn on both A13 gates. However, the gate turned on is a function of the state of the B delay. If the B delay has expired, i.e., at a high logic level, then whenever A5 is triggered its output will go to a logic "1" and thereby remove the drive from Q2.

The length of time the drive is removed is a function of the RC network, R29 and C14, and is approximately 1 millisecond.

If the overcurrent condition occurs during the B Delay period, then the other monostable gate, A6 is enabled and it removes the drive for approximately 3.5 milliseconds.

Since both time delay periods are at least twice as long as the ramp generator period, the overcurrent load and lack of drive cause the output voltage to collapse. The collapsing undervoltage condition is sensed and the regulator attempts to turn off.

Completion of the turn-off sequence, however, is dependent on the logic state of the B Delay signal. This is discussed in detail in Section 2.6. If it has expired, i.e., the regulators have been operating normally, then the turn-off sequence will be completed. If, however, the regulators are in a startup sequence, i.e., during a B Delay period, the turn-off sequence will not be completed and only drive from the passing transistors will be removed. This is called a "softstart" because the current buildup in the passing transistors is limited to a safe operating value, yet not limited sufficiently to prevent the passive transistors from charging the output capacitance to the desired output voltage level. In effect, the B Delay signal disables the shutdown flip-flop, A25 located on HVA2, for a period adequate to allow the output voltages to come within the confidence bands of the regulator.

The second higher level of overcurrent detection is accomplished by A2 on HVA3. Its output state is normally a logic "0" level, and it changes only if the current level detected exceeds the safe operating range of the passing transistors, Q6 and Q7 on HVA4, e.g., if the first level overcurrent limit circuit does not operate. A change of state triggers the SCR, CR40, which immediately removes all drive signals from the regulators.

Drive is removed by switching gates A4 and A5 located on HVA11. These gates are the same ones that are used by the overvoltage shutdown circuitry. Recognize that the SCR can only be reset by turning off all power in the cabinet from the operator panel.

2.5.4 Panel Controls

Figure 13a illustrates the front panel of the high voltage module.

The removable printed circuit boards, HVA1 and HVA2, are located on the lower left-hand side. The voltmeter, ammeter, and selector rotary switch directly above the PWB's. The muffin fan to the right of the meters, with the indicator lights, voltage adjust potentiometers and margin switch directly below.

2.5.4.1 Metering/Rotary Switch

A method is provided to monitor the voltage and current of each HV regulator. A voltmeter, M1, ammeter, M2, and a rotary switch, S3, are on the front panel of the HV module. The switch is rotated to the desired regulator and the voltage and current are simultaneously displayed on the meters.

These meters provide a convenient troubleshooting aid but are not accurate enough for setting the regulated voltages. A digital voltmeter should be used as prescribed in the Maintenance Procedures and Aids documentation.

The electrical connectors for the rotary switch, voltmeter, ammeter and shunts are shown in main frame schematic, 43D222254.

2.5.4.2 Voltage Adjustment Potentiometers

The voltage adjust knobs may be used to change the output voltages of the two bit and word regulators between +24 and +38 volts. The DT adjustment, R58, is located on HVA2. It is accessible while the PWB is in the module, but it normally needs no adjustment.

The word and bit controls on the front panel can be easily used to schmoo the magnetics memory module. Each control has a small lever that locks the potentiometer in its final position.

R19, the front panel control for the Bit #1 regulator is illustrated in Figure 16. It is the top potentiometer in Figure 10a. This figure also identifies the other bit and word controls.

2.5.4.3 Margin Switches

The margin switches are to the immediate right of the potentiometers. In the center position, these switches set the output voltages to the normal or nominal voltages specified by the magnetics module schmoo. Manually, they may be switched to either the high (left) or low (right) test positions. This will change the output voltage of the regulator by either plus or minus five percent from the nominal voltage setting.

Switch S4 for the Bit #1 regulator is shown in Figure 16. This switch connects a shunt resistor into the feedback path and changes the ratio of the error voltage.

2.5.4.4 Status Indicators

Each trip light is associated with the potentiometer and switch located to its immediate right, except in the case of the DT control which is located on HVA2.

Input power and confidence indicators are located on HVA5 and illustrated in Figure 16. The input power indicator lights only after the +12, -12, and +55 volts have been applied to the module and the voltage regulators on HVA1 operate. If this does not occur, A13, which initiates the A Delay period will not time out and the regulators cannot be turned on.

The confidence indicator is lighted whenever the circuitry on HVA2 detects that all output voltages are within their prescribed confidence bands. This indicator also monitors the same logic signal that is sent to the Core Controller.

2.5.4.5 Reset Pushbutton

The reset pushbutton is a maintenance aid and it can be used to initiate a B Delay time period if the regulators are not operating. However, the TR output voltages must be available to the module. This is, depressing this pushbutton will attempt to turn on the high voltage regulators at the module rather than from the operator's panel.

If the logic signals from the Core Controller are not correct, or a failure has occurred in the module, the regulators will be turned off when the B Delay expires. Moreover, overcurrent circuitry located on HVA3 will prevent damaging the regulators should the pushbutton be depressed repeatedly.

Refer to Section 2.7 for a discussion of the temperature warning and shutdown indicators and how they operate.

2.6 POWER SYSTEM ON/OFF SEQUENCING

2.6.1 Power ON Sequence

Before the normal power ON sequence can be initiated, it is necessary to have a-c power connected to the a-c power panel. Also, the main breaker on the front of the a-c power panel and the five breakers on the front of the TR power supply module must all be in the ON position. With these steps completed, the power system is ready to be turned on.

The normal power ON sequence is initiated by pressing the POWER ON pushbutton switch on the operator control panel. When depressed, this switch energizes circuitry in the a-c power panel as discussed in Section 2.1. This, in turn, applies a-c power to the rectifier bridges in the TR module. The bulk unregulated TR output voltages then come up and are present as inputs to the regulator modules. This is the starting point for the sequencing shown on the timing diagram of Figure 18.

Figure 19 shows the critical circuits in the memory power supply system that control each regulator's startup sequence. This sequence begins when the +15V, -15V, and +22V bulk TR voltages are present at the LV module. A logic AND of these voltages is made by All on the LVA1 PWB. This initiates a time delay designated "A Delay." This delay allows time for all LV module internal PWB power regulators to come into regulation before any further action is taken. At the end of this time period, the A Delay line goes to a logic "1" which initiates another time delay designated "B Delay."

While the B Delay is at a logic "0," all of the shutdown flip-flops in the LV module are disabled to allow the regulators to turn on. When the A Delay goes high the last condition is met to allow the regulators to turn on. The +5V regulator immediately starts up. The other three LV regulators (+4V, -5V), however, do not yet turn on. The +10V

Bulk Inputs to L.V.

L.V. Input Power Sum

L.V. "A" Delay

L.V. +5v Output

L.V. +10v,+4V,-5v Outputs

L.V. "B" Delay

L.V. Conf. to C.C.

Bulk Inputs to H.V.

H.V. Enable from C.C.

H.V. "A" Delay

H.V. Bit Outputs

H.V. Word Outputs

H.V. "B" Delay

H.V. Conf. to C.C.

Honeywell

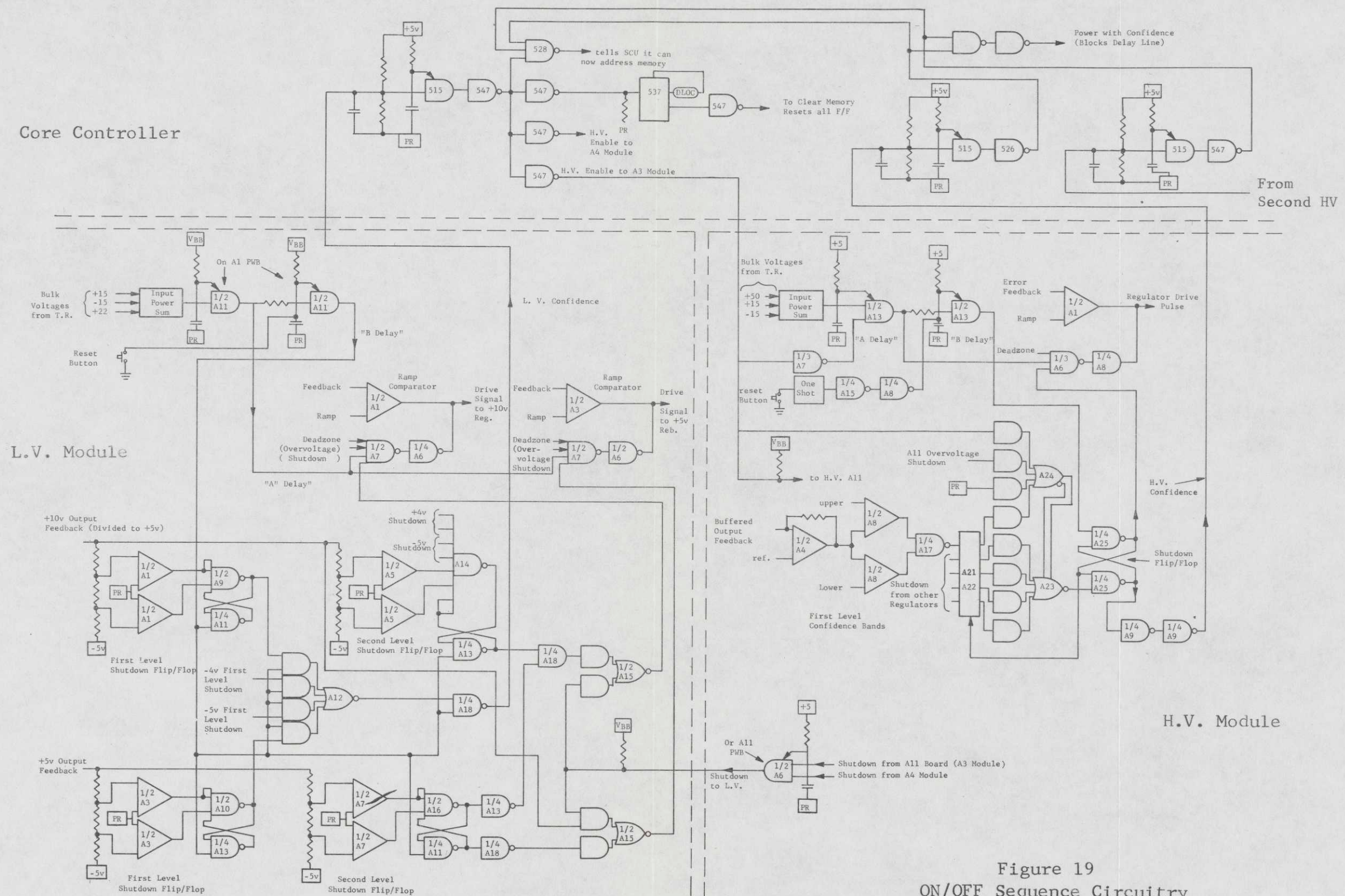
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Page 60

Figure 18. Start-Up Timing Diagram



control logic is shown in Figure 19 and is representative of these three LV channels. As is seen in the circuit layout, the A15 output, which must go high to allow these three regulators to turn on, is controlled by the second level +5V shutdown flip-flop through A18. The +5V regulator must be within 12% of its nominal setting before the other three LV regulators can turn on. As these conditions are met, all LV regulators come up and must be within the first level confidence band ($\pm 9\%$) by the end of the B Delay time-out period. If they are all within this band, all inputs to A12 coming from the first level shutdown flip-flops will be at a logic "0."

When the B Delay time-out is completed it goes to a logic "1," which sets all shutdown flip-flops. The output of A12 will stay at a logic "1" if all regulators are in confidence. This "1" and the B Delay "1" must both appear at A18 for the Low Voltage confidence signal to go to a logic "0" indicating a confidence condition. It is noticed in Figure 18 that the LV confidence line does not go to a logic "1" to indicate lack-of-confidence until the +5V output is up. A18 is an open collector gate and requires an external pull-up resistor which is in the core controller. Therefore, not until the core controller receives its operating voltage (+5V) can the LV confidence go to a logic "1."

When the LV confidence goes to a logic "0," the LV module is known to be up and in confidence so that the startup sequence proceeds to the core controller. In the core controller, the LV confidence signal goes through a one-shot filtering circuit and two inverters before triggering the memory initialize signal and generating two high voltage enable signals. The memory initialize signal clears the memory by resetting all control flip-flops. The two HV enable signals are sent one each to the HV modules. Figure 18 shows that

the HV enable goes to a logic "1" (lack-of-confidence) before the LV confidence does. An active pull-up on the HVA11 PWB pulls the enable line to a one for that period before the core controller has its +5V power. This inhibits the HV module startup until the legitimate HV enable (logic "0") is received.

When the HV enable goes to a logic "0," the HV startup begins provided the input power (+50, +15) logic signal is present at A13 on the HVA1 PWB. The presence of these two signals starts the high voltage A Delay. At the end of the time period the A Delay signal goes to a logic "1," which initiates the high voltage B Delay similar to that in the LV module. While B Delay is low, the HV shutdown flip-flop is disabled to allow the regulators to turn on, and when A Delay goes high, the five HV regulators start up.

As all regulators come into the confidence band, the inputs to A23 and A24 through A21 and A22 will all go to a logic "0" causing the A23 output to go to a logic "1." This, in turn, switches half of the shutdown flip-flop, causing the HV confidence signal to go to a logic "0," indicating confidence. This must occur before the end of the B Delay time-out or the supply will shut down.

If all regulators are in confidence, B Delay goes to a logic "1," the shutdown flip-flop is enabled and the module stays in confidence. Again, it is noticed in Figure 18 that the HV confidence signal does not go to a logic "1" to show lack-of-confidence until the +5V output is up. This is for the same reason as with the LV confidence signal.

The core controller receives confidence signals from both HV modules. They are both filtered through one-shot circuits in the core controller. When both modules are in confidence, the System Controller is told it can address the memory and the delay line block is removed. This completes a normal startup sequence.

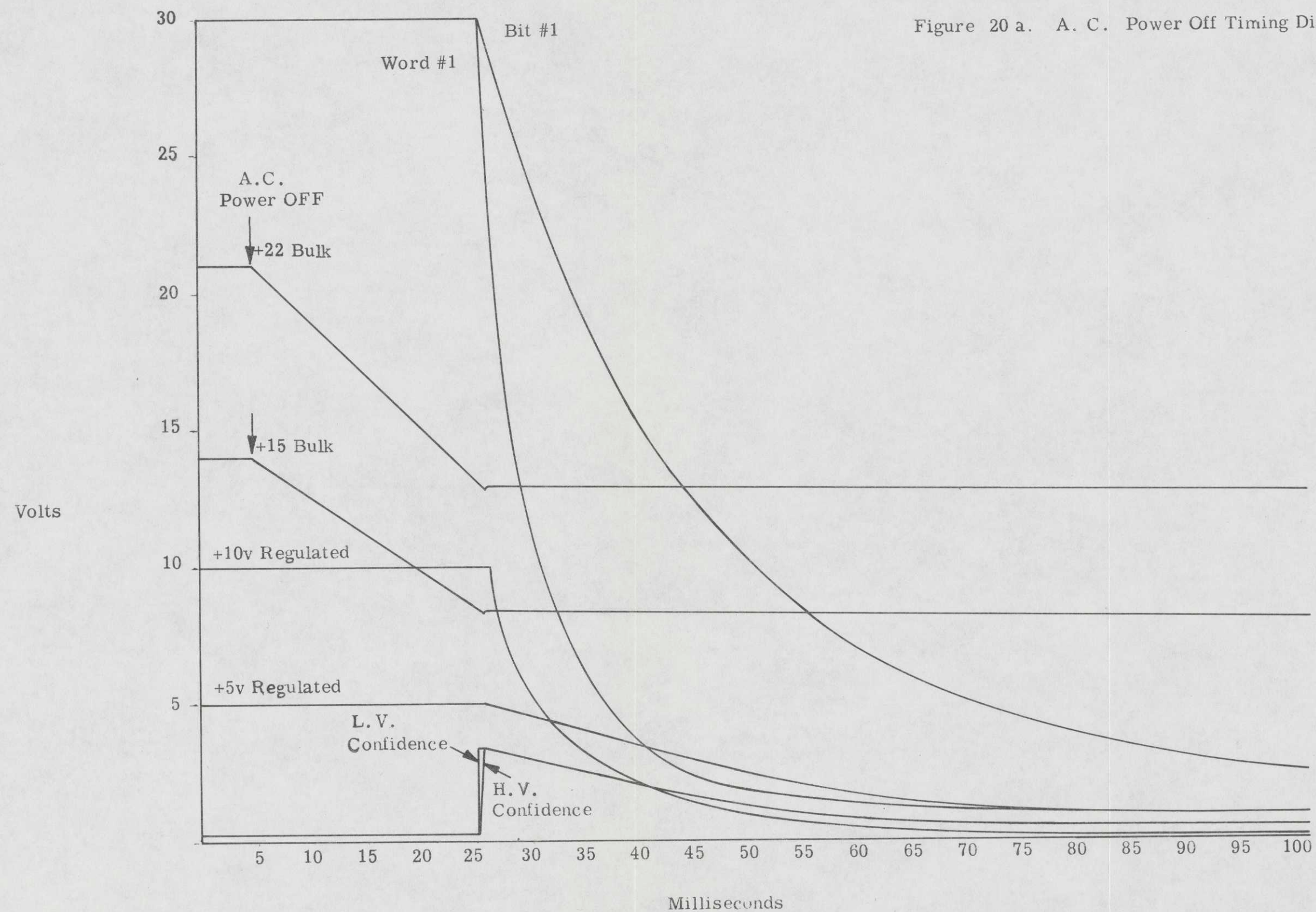
Both LV and HV modules have reset buttons on their front panels. A reset is accomplished by recycling the B Delay portion of the startup cycle in the module being reset. This gives the regulators a chance to come up into confidence within the B Delay time period.

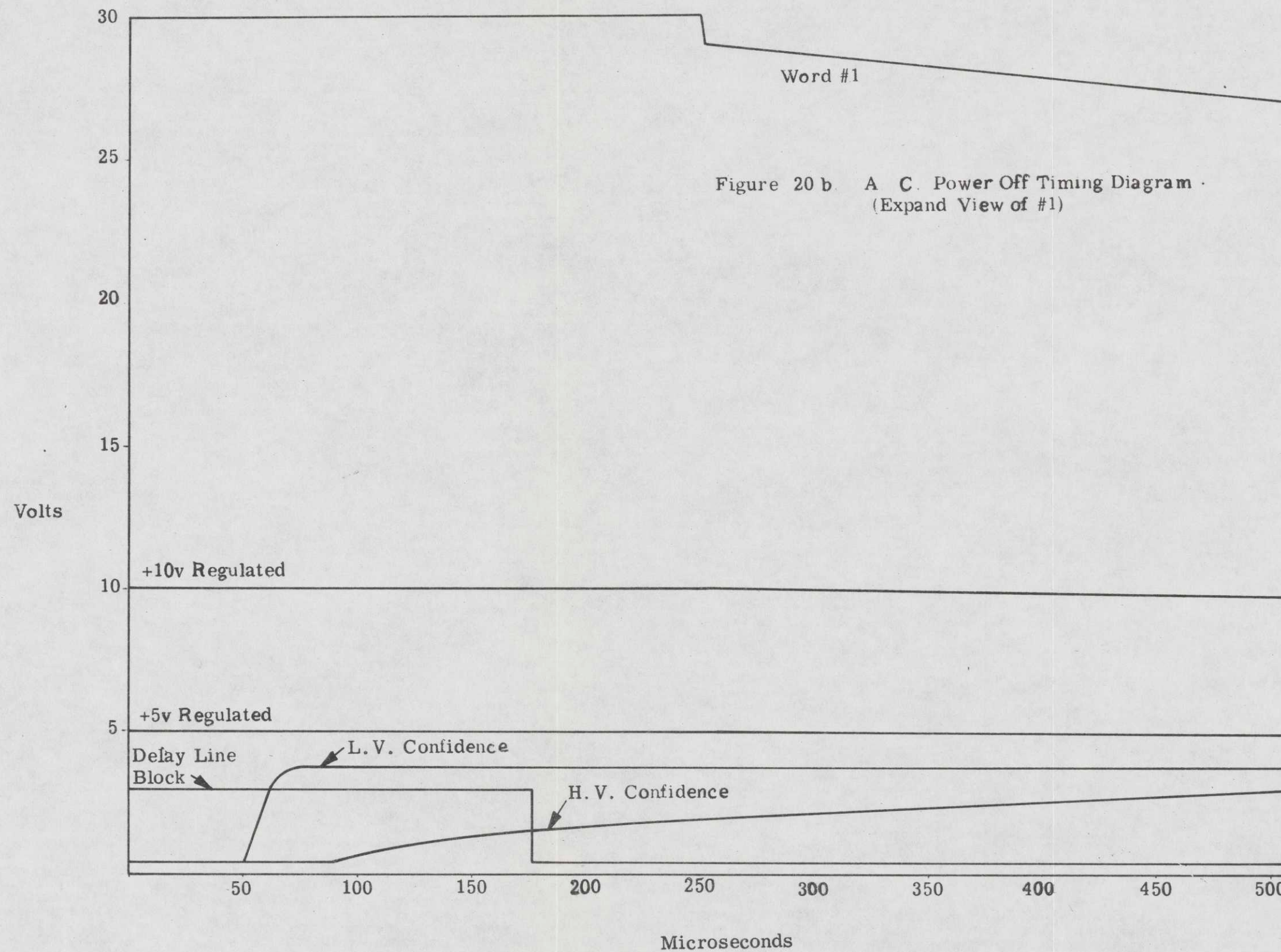
2.6.2 Power OFF Sequence

The possible shutdown conditions are: (1) a-c power shutdown, (2) over/undervoltage confidence shutdown, (3) overvoltage/crowbar shutdown, (4) overcurrent shutdown, and (5) temperature shutdown. The sequence followed in powering down is a function of where the shutdown was initiated. Under some of the above conditions a complete power down sequence is made on all regulators, and under the other conditions only a few of the regulators are shutdown. The power OFF sequencing under all of these conditions is discussed in this section with the exception of temperature shutdown which is discussed in Section 2.7.2.

2.6.2.1 A-C Power Shutdown

The normal method for powering down the memory cabinet is the a-c power off sequence, which is initiated by depressing the POWER OFF pushbutton switch on the operator's panel. Because of the data save requirement, the voltages are sequenced down in a particular order with this type of power off. When the switch is depressed, relay K2 in the a-c power panel is energized. The normally closed contacts of this relay then open, which opens the holding circuit for K1. K1 opens up, causing K5 to open, thus removing a-c power to the TR module. With input ac removed, all output voltages from the TR module will decay as shown in the a-c power off timing diagrams of Figures 20a and 20b. One of three LV regulators (+4V, +10V, or -5V) senses an undervoltage first and sends a lack of LV confidence signal to the core controller. This signal generates two lack of HV enable signals (one to each HV module) plus the signal that tells the System Controller to





stop addressing the memory. The lack of HV enable signals start the HV modules to shutdown. The drive signals to the passing sections are removed, a lack of HV confidence signal is sent to the Core Controller to block the delay lines and a 200 micro-second time-out is started after which the HV output voltages are crowbarred. The LV output voltages decay uncrowbarred, while the HV output voltages are all crowbarred.

2.6.2.2 Over/Undervoltage Confidence Shutdown

All LV and HV regulators have confidence bands around their output voltages to verify regulator operation within certain limits. A power down sequence is initiated when any regulator passes through one of these confidence bands. Sections 2.4.3.2 and 2.5.3.2 discuss the shutdown circuitry of the LV and HV modules, respectively.

The preferred power down sequence when a fault is detected is: (1) all HV regulators, (2) the +10V, +4V, and -5V LV regulators, and (3) the +5V LV regulator. The extent to which this sequence is followed depends upon whether the fault occurs in an LV or an HV regulator.

When a fault occurs in a HV regulator, all regulators in that module are powered down and a lack-of-confidence is sent from the module to the Core Controller. The shutdown sequence, however, goes no further. The other HV module and LV module remain operational. If the second HV module faults, the same shutdown action is taken on that module, and the LV module remains operational.

When any of the LV regulators fault, no immediate shutdown action is taken on them, however, a lack of LV confidence is sent to the Core Controller to stop the System Controller from addressing the memory. The Core Controller sends a lack of HV enable signal to each of the HV regulators and they crowbar down. When all HV regulators are down, a signal is sent to the LV module that tells

the +10V, +4V, and -5V regulators to power down. When the +10V output is below 1.5 volts the +5V regulator is powered down.

2.6.2.3 Overvoltage/Crowbar Shutdown

The overvoltage/crowbar shutdown is very similar to the a-c power shutdown, since the a-c power is removed from the supply at the a-c power compartment. The conditions under which such a shutdown will occur, along with the sensing and processing of the shutdown signal, are discussed in the theory of regulator operation sections of both LV and HV regulators. These sections are 2.4.3.3 and 2.5.3.3.

The over voltage shutdown circuits are combined with the overtemperature shutdown circuits as shown in Figure 22. A relay closure in any one of the supply modules due to an overvoltage by any regulator will cause the main contactor in the a-c power compartment to open as explained in Section 2.1. A-C power is therefore removed. The supply module in which the overvoltage was detected will crowbar all its regulators upon sensing the overvoltage. The other supply modules will power down just as they would under the normal a-c power shutdown.

2.6.2.4 Overcurrent Shutdown

Overcurrent shutdown capability exists only in the HV regulators. Section 2.5.3.4 explains the operation of the overcurrent sensing circuitry. When an overcurrent shutdown is initiated by one of the regulators, all regulators in that module are shutdown. The a-c power is not removed, however, and the other HV module and LV module remain operational.

2.7 TEMPERATURE CONTROL

Two levels of temperature sensing protect each power supply and magnetics module. The first is called "overtemperature warning." It operates at the lowest temperature and turns on a bell that warns the operator of the problem. The alarm may be turned off from the operator's panel; but the indication of the overtemperature condition remains until normal operation is restored. If the overtemperature persists and the temperature continues to rise, the second temperature level, called "overtemperature shutdown," protects the system by turning off either cabinet power or one of the high voltage modules.

2.7.1 Overtemperature Warning

Figure 21 is a schematic of the power system and magnetics module overtemperature warning circuitry. Normally open thermostats are used in the power system, while normally closed thermostats are used in the magnetics modules. In the LV and both HV modules, the temperature warning signal from the thermostats is used internally, while normally open relay contacts are used to send the signal externally. The three relays in the regulators and the thermostat in the TR, A1, are connected in parallel with the LV module power return common to all. A closure of any one of these contacts sends a logic "0" to the gate circuits on the A10 PWB in the LV module. Individual inputs from the temperature warning thermostats in the magnetics modules also are brought to A10. In the normally open condition, pull-up resistors send logic "1's" to these gates. The A10 board uses these temperature warning signals to energize the K3 relay in the A-C Power Compartment, which rings the alarm bell. These temperature warning signals also activate warning indicators (red) on the front panel of the LV module to show which module over-temperated.

Figure 21
Temperature Warning Circuitry

2.7.2 Overtemperature/Overvoltage Shutdown

Figure 22 is a schematic of the power system and magnetics module overtemperature and overvoltage shutdown circuitry. There are two possible actions taken when an overtemperature shutdown condition is sensed. The action taken depends on which module the shutdown condition is in. If the overtemperature originates in a magnetics module, a crowbarred shutdown is initiated in only the HV module supplying power to the overtemperated magnetics. The a-c power is not removed and the other half of the memory remains operational. As shown in the schematic, two normally closed thermostats, one in each magnetics module, are connected in series and returned to the corresponding HV module. An open on either of these shuts off that half of the memory. If an overtemperature shutdown originates in any one of the power system modules, then all a-c power is removed by operating the power off relay, K2, in The A-C Power Compartment.

Since the overvoltage shutdown circuitry also removes all a-c power when operated, it is connected in parallel with the power system overtemperature circuitry. The same power off relay, K2, is activated to remove all a-c power. Refer to Section 2.6.2.3 for a discussion of an overvoltage/crowbar shutdown.

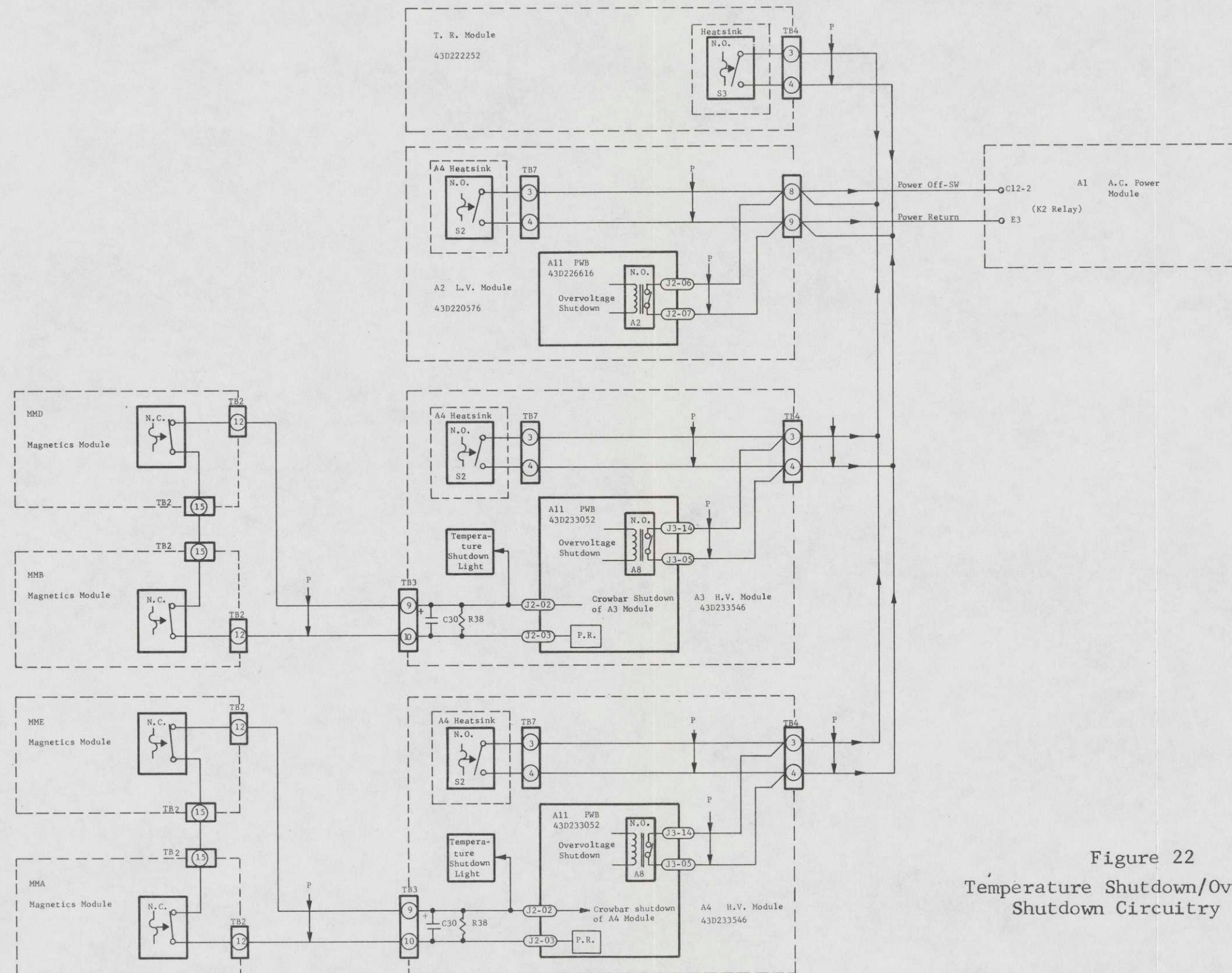


Figure 22
Temperature Shutdown/Overvoltage
Shutdown Circuitry

2.8 LAMP DRIVER CIRCUITRY

Figure 23 is the schematic diagram of the lamp driver.

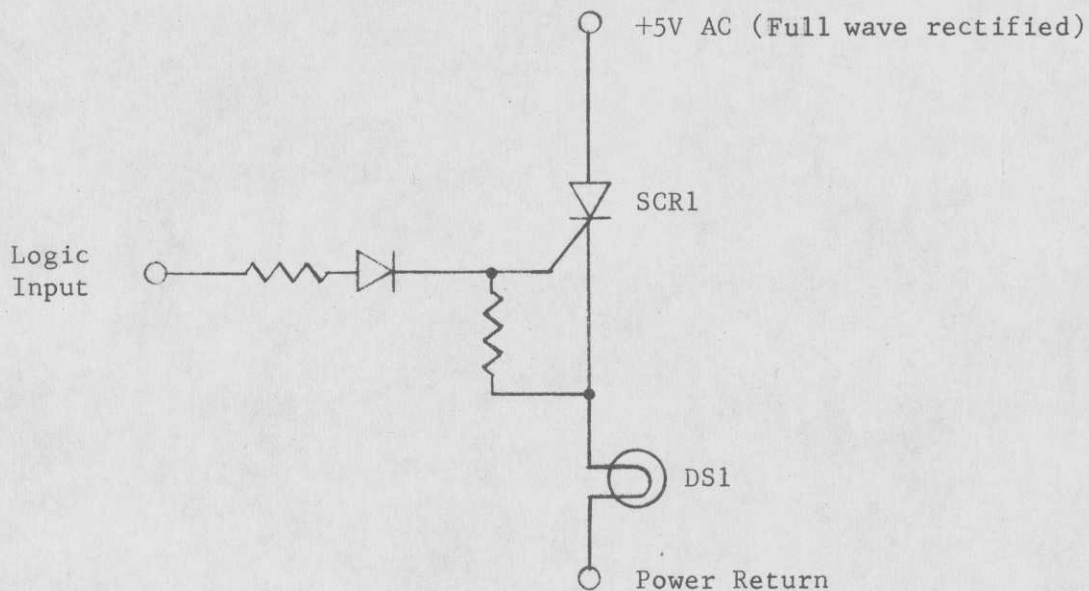


Figure 23 - Lamp Driver Circuitry

The lamp DSI is actuated by the application of a logic "1" signal at the logic input. When the signal on the gate of SCR1 reaches +1.1 volt, it is turned on and power is passed through lamp DSI to light it. The light remains on as long as the logic input remains. When this input goes to zero, the holding current keeps the SCR on until the end of half a cycle. The anode to cathode voltage drops to zero and the SCR is turned off. This, in turn, extinguishes the lamp.

Four lamp driver circuits are mounted on each lamp driver PWB (43C228027).

3. MAINTENANCE CONSIDERATIONS

For memory maintenance routines, refer to "6000 Core Storage Unit, Maintenance Procedures and Aids Introduction" called out in publication MEM-040-139. Routines in this document that are pertinent to the memory power systems are as follows.

3.1 PERFORMANCE CHECKS

Routine 4.4 (Part IV) verifies the "Four Corners of the Schmoo" undervoltage margins and running T&D. Margin configurations are as follows:

1. High Bit & High Word
2. Low Bit & High Word
3. High Bit & Low Word
4. Low Bit & Low Word

3.2 MAINTENANCE CHECKS

Routine 2.1 verifies the nominal and margin voltage tolerances.

Routine 2.2 verifies the LV (Low Voltage) and reference voltage tolerances.

3.3 ADJUSTMENT PROCEDURES

Routine 4.3 calls out the method of adjusting LV (Low Voltage) and reference voltages.

Routine 4.4 (Parts I & II) call out the method for adjusting Bit and Word voltages on the HV (High Voltage) regulators while adjusting strobe timing and performing a schmoo for anyone of four magnetics modules.

3.4 DISASSEMBLY AND REPAIR

Routine 5.3 calls out the method for removal and replacement of HV (High Voltage) and LV (Low Voltage) regulators.

Routine 5.8 calls out the method for removing and replacing a TR (Transformer Rectifier) module.

3.5 MAINTENANCE AIDS

Routine 6.6 describes thermal alarm circuit problems and methods of troubleshooting.

Routine 6.7 describes thermal and overvoltage shutdown circuit problems and methods of troubleshooting.

4. INSTALLATION REQUIREMENTS

For memory installation, refer to "6000 Core Storage Installation" publication MEM-040-138. This procedure gives instructions for the initial installation of either a 32K or 64K memory unit. Power, performance and system checks are also included in this document.

Routines 2.1, 2.2 and 4.4 (previously discussed) are all referred to in the memory installation procedure for checking out memory performance.

Routines 5.3 and 5.8 (previously discussed) are also referred to in the memory installation procedure. These routines are to be used when the memory unit has been shipped horizontal and the power supplies (LV, HV and TR) have to be installed or replaced.

5. APPENDIX

5.1 POWER SUPPLY ELECTRICAL SPECIFICATIONS

	<u>LV Module</u>				
	<u>+5V</u>	<u>-5V</u>	<u>+10V</u>	<u>+4V</u> <u>Reg.</u>	<u>+5VAC</u>
Output Voltage Normal	+5V	-5V	+10V	+4V	*5VAC
Output Current Design Maximum	40A	10A	10A	2.0A	6A
Adjustment Range (Minimum)	+5-4%	+5-4%	+5-4%	<u>+30%</u>	---
Margin Percent of Set Value	<u>+5%</u>	<u>+5%</u>	<u>+5%</u>	<u>+5%</u>	---
D-C Load Regulation 10 to 100% Load	+0-3%	+0-3%	+0-3%	+0-3%	+ 6% -14%
Total Tolerance 1000 hours, Load Transients, Temperature, Line & Load Variations	<u>+2%</u>	<u>+2%</u>	<u>+2%</u>	<u>+2%</u>	<u>+15%</u>
Ripple***	50mv _{pp}	50mv _{pp}	100mv _{pp}	50mv _{pp}	*
Spikes on Ripple***	300mv _{pp}	300mv _{pp}	300mv _{pp}	300mv _{pp}	**

*Rectified ac without filtering

**Not defined

***At constant rated current

HV Module

	<u>Bit 1</u>	<u>Bit 2</u>	<u>Word 1</u>	<u>Word 2</u>	<u>DT</u>
Output Voltage Nominal	33	33	33	33	32
Output Current Design Maximum	20	20	1	1	2.0
Adjustment Range Minimum	24-38V	24-38V	24-38V	24-38V	$\pm 5\%$
Margin Percent of Set Value	$\pm 5\%$	$\pm 5\%$	$\pm 5\%$	$\pm 5\%$	$\pm 5\%$
D-C Load Regu- lation 10 to 100% Load	+0-3%	+0-3%	+0-3%	+0-3%	+0-3%
Total Tolerance 1000 hours, Load Transients, Temperature, Line & Load Variations	$\pm 2\%$	$\pm 2\%$	$\pm 2\%$	$\pm 2\%$	$\pm 2\%$
Ripple*	250mv _{pp}	250mv _{pp}	250mv _{pp}	250mv _{pp}	250mv _{pp}
Spikes on Ripple*	300mv _{pp}	300mv _{pp}	300mv _{pp}	300mv _{pp}	300mv _{pp}

*At constant rated current.

5.2 POWER SYSTEM DRAWINGS

<u>Module</u>	<u>Drawing No.</u>	<u>Title</u>
Operator's Panel	43C228270	Assembly (Control Panel)
	43D223744	Assembly (Maintenance Panel)
	43C226986	Schematic (Maintenance Panel)
	43C228273G2	Assembly (Panel, Control)
	43D233420	Schematic (Panel, Control)
Care Package	43D228350	Assembly
	43D228352	Schematic
Wiring	43D231888	Cabinet Wiring Schematic
	43D222251	Supply Wiring Schematic
Transformer Rectifier	43D222260	Assembly
	43D222252	Schematic
Low Voltage	43D222270G2	Assembly
	43D220576	Schematic
	43D228544G1	A1 PWB Assembly
	43D228545	Schematic
	43D231940G1	A2 PWB Assembly
	43D231941	Schematic
	43D228118G1	A3 PWB Assembly
	43D222257	Schematic
	43C228025G1	A5, A6, A9 PWB Assembly
	43C228027	Schematic
	43C228067G1	A7 PWB Assembly
	43C228065	Schematic
	43B227426G2	A10 PWB Assembly
	43B233729	Schematic
	43D226615G2	A11 PWB Assembly
	43D233598	Schematic
	43C220145G2	A12 Subassembly
	43C220146	Schematic

<u>Module</u>	<u>Drawing No.</u>	<u>Title</u>
High Voltage	43D222280G2	Assembly
	43D223546	Schematic
	43D228554G4	A1 PWB Assembly
	43D233084	Schematic
	43D228559G2	A2 PWB Assembly
	43D236634	Schematic
	43D220590G1	A3 PWB Assembly
	43D220591	Schematic
	43C228025G1	A5, A6, A7 PWB Assembly
	43C228027	Schematic
	43C232850G1	A9 Subassembly
	43C233547	Schematic
	43C210779G2	A10 Subassembly
	43D233050G2	A11 PWB Assembly
	43D233428	Schematic

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Page 80F

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